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THE ATMOSPHERE OF VENUS.*

By ALFRED RORDAME.

Astronomers in studying the atmospheres of the planets of the solar system are compelled to adopt quite a different method from that of the meteorologists investigating the atmosphere of the earth. They are forced to observe from beyond the outer limit of the gaseous envelopes and thus determine their composition by the aid of the telescope and spectroscope.

We cannot deny that the chemical elements common to the earth are also general in the whole solar system (and in the whole visible universe for that matter) and that the bulk of these elements is contained in the sun. Whatever theory of planetary evolution we adopt, it seems almost certain that the atmospheres of the outer planets, Jupiter, Saturn, Uranus and Neptune have retained the gases prevalent in the outer atmosphere of the sun, notably hydrogen. Slipher, who has photographed the spectra of the outer planets, believes that certain strong absorption bands in the spectra of Uranus and Neptune correspond to the (F) and (C) lines of hydrogen. Because these bands are very broad and diffuse, it is difficult to identify them with certainty. On these planets the atmospheres gradually merge into the interior gas-masses so that no distinct boundary exists between the rarer and denser layers. The condition of the atmospheres of the inner planets, Mars, Earth and Venus is quite different. Here a cool dark body defines the lower limit of the air, which, because of their comparatively small masses, contains only a slight percentage of hydrogen.

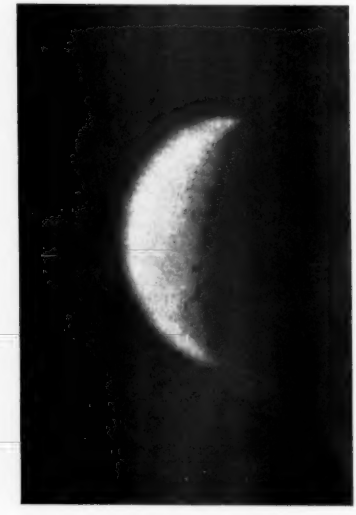
The composition of the atmosphere of one of these planets, the earth, we know consists of a mixture, not a union, of at least ten substances. The chief constituents are oxygen and nitrogen. It also contains water vapor, carbon dioxide, argon, krypton, hydrogen, neon, xenon and helium, besides dust and germs.

Let us briefly review the evidence given by spectroscopic investigations as to the constitution of the atmosphere of Venus;—evidence looked upon by most astronomers engaged in this class of work as gospel truth, to be relied upon with mathematical certainty. Let us see how much weight can be given to their findings in the case of the planets Venus and Mars.

The spectroscopic evidence of the constitution of the atmosphere of

*Address given at the meeting of the American Meteorological Society at Salt Lake City, June 23, 1922.

PLATE XXXI



VENUS PHOTOGRAPHED BY RORDAME.

Enlargement of original negative taken March 14, 1921, 7:30 P. M., with 16-inch Mellish reflector.

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The spectroscopic evidence of the constitution of the atmosphere of

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Mars has been the subject of investigation by Slipher at Flagstaff and by Campbell in California.

If the spectroscope is directed at the sun when at a low altitude, a number of lines will be seen, which have their origin in the earth's atmosphere. They are mostly due to oxygen and water vapor, and are especially abundant in the red and yellow portions of the spectrum. These are called "telluric" lines or rain bands, and are more strongly developed in humid air. If we direct the instrument first to the moon, which lacks an atmosphere and is of too small a mass to retain water vapor, and then to Mars, we should perceive a marked difference, provided moisture is present in the atmosphere of Mars. The rain bands ought to be more pronounced in the sunlight which has twice passed through the atmosphere of Mars than in light reflected from the airless moon. The bands appear of course in both spectra, as the light finally entering the spectroscope passes through the atmosphere of the earth, which never is free from moisture. Two world-famed astronomers, Huggins and Janssen, believed that they had demonstrated the presence of water vapor in the atmosphere of Mars in this manner; but Campbell and Marchaud, two equally famous scientists, made similar investigations under much more favorable circumstances, and neither found any indications of moisture in the spectrum.

Slipher at the Lowell Observatory photographed the spectrum of Mars in January and February, 1908. He found that the most important rain band, designated (A), located at the red end of the spectrum, was always more prominent in the spectrum of Mars than in the spectrum of the moon photographed later during the same night.

In 1909 Campbell equipped an expedition to Mount Whitney, 14,502 feet high, having among his associates Dr. Abbot, head of the Smithsonian Astrophysical Observatory, and Sebastian Albrecht, assistant at the Lick Observatory, his object in ascending to this height being this, that the water vapor content of our air at this high altitude is from 2.5 to 4 times less than at the Lowell Observatory. The spectra of the moon and Mars were photographed in close succession, two exposures being made in each case. No indication of greater prominence of the (A) band in the spectrum of Mars could be found. Other rain bands were also investigated with the same result.

Slipher made spectrograms as late as 1914 and again claimed intensification of oxygen and water vapor bands in the Martian spectrum.

The difficulty with this method of measurement lies in the fact that the absorption lines of water vapor in the atmosphere of Mars occupy the identical place of the lines due to vapor in the earth's atmosphere.

As early as 1896 Campbell pointed out a method of separating the lines due to the two planets, on the well known Doppler principle, when a planet either approaches or recedes from the earth with sufficient velocity. The advantage of this method is evident, as the Martian and telluric lines lie close beside each other on the same plate so

that differences due to sensitveness of the emulsion, exposure and atmospheric conditions are entirely eliminated. Professor Campbell on January 26 and 27, 1910, used this method and found absolute absence of lines due to oxygen and water vapor on Mars. This is the method since used on Mt. Wilson by St. John and Nicholson in the case of Venus.

The earlier spectroscopists announced the presence of water vapor in the spectrum of Venus but the observers at the Lowell Observatory, as well as St. John and Nicholson at Mt. Wilson, claim absence of the lines of water and oxygen in the planet's spectrum.

Successful application of the spectrograph to the determination of the rotational periods of the planets have been made of Saturn, Jupiter and Mars, while the rotational periods of Uranus, Neptune and Mercury, have never been determined. According to Belopolsky, who applied the spectrographic method to the study of the rotation period of Venus, the average equatorial velocity observed by him was 500 meters per second, which corresponds to a rotation period near 24 hours, while at the Lowell Observatory Slipher's spectrograms indicated a velocity of 5 to 8 meters per second, which corresponds to a long rotation period, though one much shorter than 225 days, which would show an equatorial velocity of about 2 meters per second.

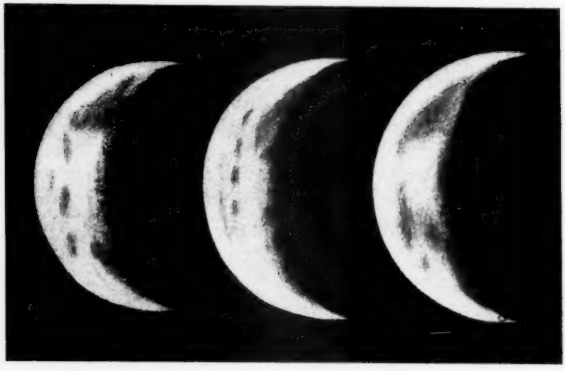
In all this contradictory evidence as revealed by the spectroscope, the two results that merit the greatest confidence are those of Campbell in the case of Mars, and of St. John, showing the utter absence of water vapor lines, in the case of Venus. In the case of Mars the result of Campbell's investigations means the real absence of water vapor in any sufficient quantity that is capable of being detected by the spectroscope. According to calculations made by Dr. Johnstone Stoney, who bases his method on the kinetic theory of gases, the smaller planets and the moon are gravitationally incapable of retaining all of the gases that go to make up our own air covering. Among the atmospheric constituents that Mars would be unable permanently to retain is water vapor.

In the spectrum of Venus the presence of the lines of water vapor is masked by the intensity of the reflected light from the outer layers of the planet's atmosphere.

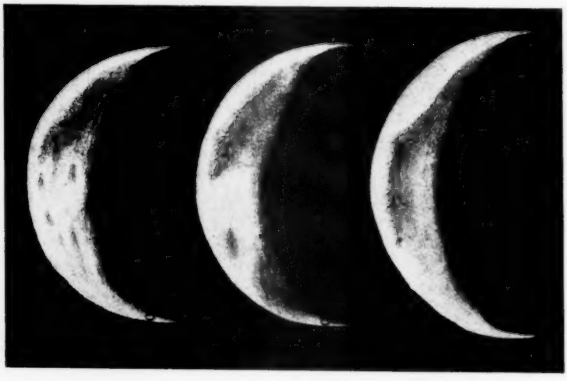
Concerning the earth, it is known that a very high percentage of the light from the sun that enters the outer atmosphere is reflected back into space without first penetrating to any great depth in the atmosphere. If we were viewing our earth from Venus, it is doubtful whether we would be able to make out any details of the permanent features of the surface, as the largest percentage of light that is reflected into space has never penetrated the lower strata of our atmosphere.

The evidence presented by the published drawings of Venus by astronomers using the telescope we shall find just as contradictory as

the results obtained by the aid of the spectroscope, until we call meteorology to our aid in explaining them. If we analyze the majority of drawings of Venus we shall find a similarity of general features delineated. Broad dusky patches are usually represented, having a marked northeast to southwest elongation from the terminator in the



March 22, 6h March 26, 7h March 28, 6½h



March 30, 6¾h March 31, 6¾h April 5, 6¾h

VENUS, 1881 (W. F. Denning).

northern hemisphere and a contrary direction in the southern, so that if they were prolonged they would nearly meet at the equator. Lowell draws these markings in the same manner, with this difference, that they are represented as straight lines on a flat surface, all meeting at the equator like the spokes of a wheel. Recent photographs which I have secured show this shadowlike marking as a diffuse elongated band.

PLATE XXXII

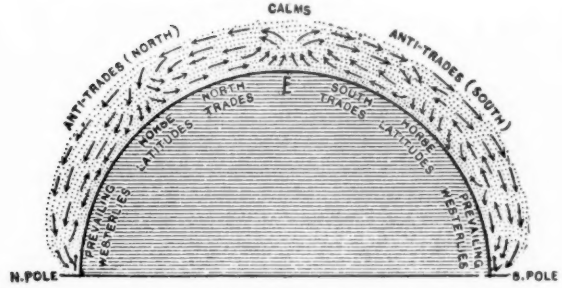
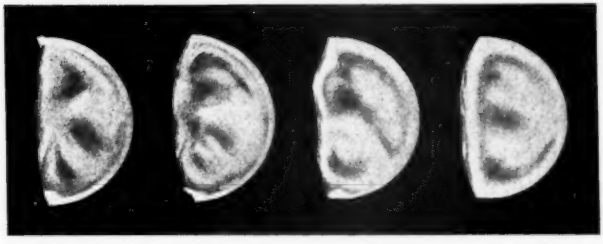


DIAGRAM ILLUSTRATING THE AIR CIRCULATION OF A QUICKLY ROTATING PLANET.



VENUS AS DRAWN BY MASCARI IN 1892.

OCTOBER 23 OCTOBER 25 OCTOBER 25

THE DISK OF VENUS IN 1896 (LOWELL).

If we make a drawing of the earth as we should expect to see it from a point in space outside of the atmosphere, we shall find, if we represent the clear places, where the trade wind blows, by dark shadings, that we have an almost exact representation of Venus as drawn by the most expert observers of the planet, like Trouvelot, Mascari, Denning and Stanley Williams, whose drawings appear very much alike. We must not make the mistake of representing the continents in clear outline as we so often see the earth represented, because we would not be looking through an atmosphere like that of Mars, which is very thin and transparent and where clouds are very rarely present.

From all the contradictory evidence presented by the observers using the spectroscope and telescope, we can form no definite judgment concerning the atmosphere of Venus; but from a little study of meteorology and the physics of the atmosphere of the earth we are able to arrive at a sensible conclusion as to conditions prevailing there, by reasoning from analogy. At times of transit of Venus across the sun's disc, a ring of light is seen surrounding the planet. This is proof positive that Venus possesses an atmosphere. A circumstance of great moment in this connection is the fact that this ring of light should appear of much greater extent than has been observed, providing the atmosphere of the planet was clear and if the whole amount of the solar rays penetrated to the surface of the planet before being reflected; but, as it does not so appear, we know that Venus is surrounded by a cloudy envelope that effectually screens the planet from the fiery solar rays. The albedo of Venus, variously estimated at from 0.65 to 0.75, is the albedo of terrestrial clouds and shows us that the major portion of sunlight is reflected into space, allowing only a small percentage to reach the planet beneath.

The characteristic, diffuse, shadowlike markings shown by the drawings made by astronomers, and also by photography, can only be interpreted on the assumption that Venus, like the earth, is a quickly rotating planet and that its atmosphere is subject to the same laws that govern our own. Ascending currents at the equator produce dense clouds which deposit snow and ice at the poles, and the only clear places on the planet are those zones corresponding to our trade wind regions. Light and heat being of twice the intensity prevalent on the earth, evaporation and consequent cloud formation takes place to a much greater extent there than here. The clouds form at an immense height in the atmosphere as compared with those of the earth and the heat of the solar rays has lifted the water vapor to such an extent on Venus that the oxygen content of the atmosphere lies almost entirely below the cloud envelope. Water vapor we must remember is nearly twice as light as oxygen. The stratosphere of Venus, therefore, is comparatively shallow, as is manifest by the narrowness of the ring of light seen during transit. The spectroscope is capable of penetrating this isothermal layer but if the condition of the stratosphere of

Venus is similar to that of the earth, we can readily account for the failure of obtaining absorption lines in the spectrum and, should any lines be present of an intensity sufficient to bear measurement, we will then obtain a rotation period of several days in length.

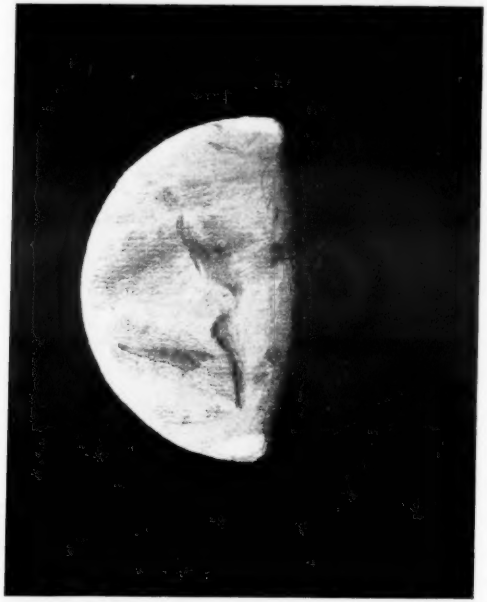
"The stratosphere of the earth has received its name from the fact that it consists of strata lying parallel to the earth's surface and moving in a horizontal direction, while vertical motions are absent. The air currents in these strata have a marked westerly direction, that is, they are east winds, moving contrary to the direction of the earth's rotation, and they become stronger with increase of altitude—at 52 miles their velocity is about 330 ft. per second. In the troposphere on the other hand west winds predominate. The wind direction in the stratosphere was observed from the so-called luminous night clouds, which were found as high as 50 miles above the earth. These strata consequently revolve slower around the earth's axis than the solid body of the planet itself. At an elevation of 50 miles the rotational speed has decreased to 65 per cent of the angular velocity of the earth's surface. We have reason to believe that the very highest strata are stationary and do not take part in the earth's rotation on its axis. This would follow if outside space were not entirely free from vapor so that our atmosphere would merge imperceptibly into the exceedingly attenuated gas masses of interplanetary space." (Arrhenius).

At least 75 per cent of the total light from Venus is reflected from the upper surface of the clouds, which defines the upper limit of the stormy and turbulent troposphere, of much greater depth than the stratosphere. It is the troposphere of Venus that contains the bulk of the oxygen, nitrogen and water vapor.

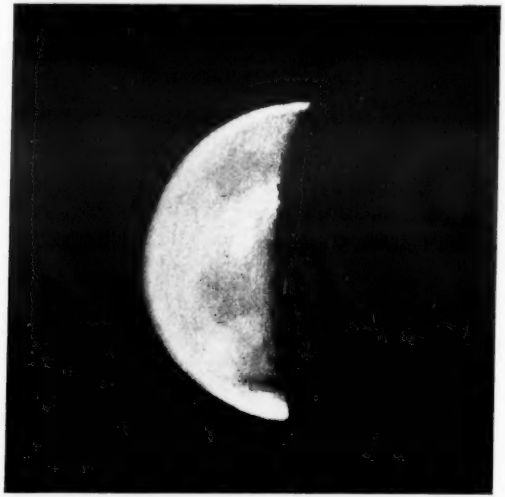
As to the existence of free oxygen in the atmosphere of Venus, it must follow as a matter of course, for given a moist damp climate such as must prevail on the greater portion of the planet's surface, the action of sunlight would be the same there as on our own earth. Here we know that a process has taken place where by the aid of sunlight the plants have built up their framework by consuming carbon dioxide, water and a little ammonia and setting the oxygen free. We also know that while the free oxygen in our atmosphere amounts to about ¼ by weight of the total bulk of the air, yet this quantity is small compared with the amount of oxygen that combined with hydrogen forms water. The oceans in fact contain 1000 times more oxygen than the entire atmosphere. Then there is the enormous quantity of oxygen locked up in the earth's crust, entering into the composition of a great variety of rocks; the total amount being estimated at ten or even twenty times the amount in the sea. We have no reason to think that Venus differs from the earth in composition or that its air covering consists of any different gases than those that are present in our own atmosphere.

As all observers of the planet Venus are agreed that it is surround-

PLATE XXXIII



THE EARTH AS VIEWED FROM THE MOON.



VENUS, 1917, NOVEMBER 18, 5:30 P. M.
Drawn by Rordame with 16-inch reflector.

ed by a gaseous envelope, it would be the height of absurdity to think that the planet could constantly turn one face to the sun and still retain an atmosphere. As soon as synchronism of revolution and rotation was attained the intense heat produced by the constant action of the solar rays would quickly force the air around to the intensely cold side where it would be solidified and prevented forever more from evaporation, resulting in a covering of solidified gases and leaving the surface of the sunlit side in a state of nakedness, as we now see the moon. The albedo would fall to that of Mercury or the moon instead of showing the brightness of terrestrial clouds.

It has been stated that the solar tides acting through the ages would produce the same condition in the case of Venus that the tides caused by the earth have produced upon the rotation of the moon. But according to Crommelin the combined action of the moon and sun upon the earth equals if not exceeds that of the sun acting upon Venus, so that it is very difficult to understand how the long rotation period could have been produced. In all probability the two planets, Earth and Venus, began life with similar rotation periods. They are very similar in size, mass and position in the solar system; and if Venus began her career with a rotation period anything like that of the earth, it is almost inconceivable that the solar tides should have been capable of lengthening it to 225 days.

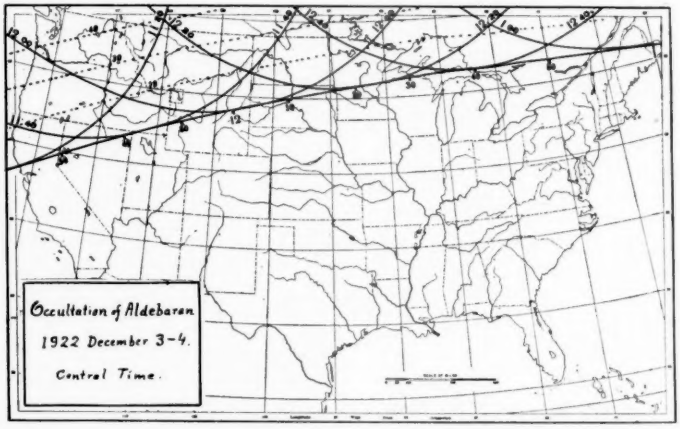
Another circumstance that has been declared in favor of the long rotation period is the want of oblateness in the case of Venus. When we remember that the oblateness of the earth amounts to only 27 miles from pole to pole, we can form some idea of the extreme accuracy of the measurements necessary to detect this comparatively tiny quantity from a distance, so that it is not surprising that the oblateness of Venus has not yet been measured, the angle subtended by this planet at superior conjunction amounting to only nine seconds.

THE OCCULTATION OF ALDEBARAN, 1922, DECEMBER 3-4, AS VISIBLE IN THE UNITED STATES.

By WILLIAM F. RIGGE.

The occultation of Aldebaran on the night of December 3-4 next will take place under rather adverse circumstances, since the Moon will be only about five hours from being full, and only the most northern and western states will get to see the occultation at all. The annexed map will give the particulars.

The limit line is self-explanatory. The numbers on it indicate for every ten minutes the times of the grazing contact, the large 12 and 1 meaning 12 o'clock P. M. or midnight, and 1 A. M., Central Time. The curves marked from 11 :20 to 1 :00 give, in their eastern or right parts, the times of the immersion, or the beginning, for every 20 minutes,



and in their western or left parts, the times of emersion, or the end of the occultation. The dotted lines, 40, 30, 20, indicate the position angle of the point of emersion or reappearance of the star as measured from the Moon's south point toward the west. On the limit line this position angle is about S 7° E. Position angles between S 20° W and S 7° E may be obtained by estimation from emersion-time curves, since these are in reality the stellar shadows of the Moon's disk.

THEORIES ON THE NATURE OF METEOR TRAINS, WITH A NOTE ON PROFESSOR TROWBRIDGE'S CONTRIBUTIONS TO OUR KNOWLEDGE OF METEOR TRAINS.

By MABEL WEIL

1. Introduction.

The purpose of this paper is a discussion of the various theories which have been advanced to explain the nature of the persistent luminosity of meteor trains, as well as an account of the theory of the late Professor Trowbridge (who died in June, 1918) that the meteor train is a gas phosphorescence phenomenon, which he based on his experimental and statistical researches in this field.

For the past century and more, many hundreds of meteors have been observed to leave in their track a bright glow, usually yellowish or greenish in color, and when faint appearing white. This glow has persisted from a few seconds to thirty minutes after the disappearance of the incandescent nucleus and in some unusual cases from one to two hours. The trains drift and become distorted by the currents of the

upper regions of the atmosphere, often expanding to many times their original size.

Apparently there have been very few papers dealing specifically with the subject of meteor trains published earlier than those of Professor Trowbridge in 1906 and 1907. There is a short article by Schmidt in the "Sitzungsberichte der Wiener Akademie," 1862, entitled "Neuere Beobachtungen von Sternschnuppenschweifen" containing a description of five meteor trains. Others have been published by Ennis in 1871 (Proc. Amer. Assoc. Adv. Sci.) and Barnard in 1883 (Sidereal Messenger) giving a description of a few trains, the latter being a distinct contribution to the subject. A great deal of space has been devoted to persistent trains in the publications on meteors by Professors Olmsted and Newton of Yale College and by Herschel of Glasgow, Schmidt of Athens, Denning of Bristol (England), and a few others; but no attempt to correlate the observations of others was made by them or to start an investigation to solve the riddle of the long enduring glow. In addition to the article by Schmidt mentioned above, the other leading papers dealing largely with meteor trains are those by Foerster in 1890 and Bornitz in 1901, both in "Sirius," and both far less extensive than a catalogue compiled by Professor Trowbridge and the present writer. Among the older works, the book of Quetelet on meteors entitled "Catalogue des Principales Apparitions d'Etoiles Filantes," published in Brussels in 1839, contains an account of many trains accompanying the meteors described.

Almost all of the observers of these meteor trains have passed over the phenomena in their reports as inexplicable, but it is fortunate that in most cases, being trained astronomers, they took careful notes on the features of the trains. In the course of the collection of the data relating to the subject, suggestions and theories of the origin of the mysterious luminosity have been found in the various publications on meteor observations, and they are brought together here for the purpose of record as well as discussion.

2. Outline of Hypotheses.

Several hypotheses have been advanced to account for the mysterious luminosity of persistent meteor trains but none have been accepted as the true explanation of this curious phenomenon. A. S. Herschel in referring to meteors states that "the nature of their light, and of the luminous streaks which they leave behind them, must however yet be acknowledged to remain a mystery." The principal hypotheses will be outlined separately and references will be made to the statements and suggestions of various investigators. The hypotheses most frequently advanced have been the incandescence, phosphorescence, electrical, reflection and chemical theories. Before going into these in detail, it might be of interest to mention two of the very earliest theories advanced on the subject.

The evidence presented by the published drawings of Venus by

The first of these appears in a Latin tract published by John Frederick Weideler and Christian Samuel Rhostio in 1731, describing a meteor observed both in Spain and in Germany. The tract, which is entitled "De Meteore Lucido Singulari a 1731 M. Octobri Conspecto qua Observationes Madritensis et Vitembergensis inter se comparantur," contains some extremely interesting descriptions of a very remarkable meteor train. In this tract it is intimated that the meteor train is a residuum of the aurora borealis which was blown by the wind into the west. The second tract by Silberschlag, published in 1764, is entitled "Theorie der am 23 Juli 1762 erschienenen Feuer Kugel." In this article the author intimates that the train consists of pieces torn off from the body of the meteor. He explains the luminosity by a chemical theory, citing simple experiments with sulphur and phosphorus placed in water as presenting an appearance similar to that of a luminous body with a train or tail. He further states "If resinous, gummy, oily solutions are observed in the cold, not only gradually falling spheres are observed, but also those which draw a train after them. Therefore we must consider the slimy atmosphere as a gas which is rare throughout, but which is more dense beneath, where it borders on the water-atmosphere than it is above, in which at times, delicate slimy threads or very thin webs and fine surfaces fly about and so soon spread out, which collect, mix together and fall as slime. In this way the slime of the shooting stars arises in the brightest sky."

3. The Chemical Theory.

It must be noted that the explanation advanced by Silberschlag is the very earliest statement of a chemical theory. It is of interest to observe that he cites experiments on which he bases his conclusions. The next investigators to advance a chemical theory were Secchi and von Konkoly. The former in 1868, on the basis of spectroscopic investigations, concluded that meteor trains contained vapors of sodium and magnesium. Von Konkoly (1874) believed that he had observed the spectrum lines of sodium, magnesium, lithium and other elements in meteor trains. A chemical theory is also suggested in the article by Meydenbauer (1886) on three observations, a translation of a portion of which follows:

"I distinctly observed that the mass after sudden extinction continued in its path for a little way in the form of a gray vapor. This observation, which is probably new, proves that the meteor is consumed almost up to the surface. The transition from white light to gray, a small portion of visible cloud, appeared exactly as can be observed on the combustion of magnesium powder."

The theory of Silberschlag, although interesting historically, is antiquated and absolutely untenable, and that of Meydenbauer is also without foundation. The work of von Konkoly and of Secchi is discussed in another paper entitled "Meteor Train Spectra", where it is

shown that the work of both was qualitative and that of von Konkoly highly inaccurate and even unscientific; and that there is no reason for believing that meteor trains contain the chemical elements which they thought they had observed. The chemical theories therefore which have been advanced are apparently without foundation and may be discarded.

4. Incandescence Hypothesis.

It has been suggested that the light which sometimes emanates from the train long after the meteor has passed is due to the heated particles of solid and gaseous matter of which the train is composed, and which, slowly cooling, send forth the glow which is observed. The suggestion has also been made that the air itself becomes highly luminous by being heated to incandescence by the flight of the meteor at a high velocity. One statement of this view is given by Baden-Powell in the Report of the British Association for 1856. A portion of his remarks follows:

"Probably the great speed causes a peculiar property of the upper regions to ignite, at the instant of ignition being an intense blaze, and then subsiding into a phosphorescent flame, which may linger for a length of time and be wafted along by currents of air, as was the case in several instances."

A clearer and more logical exposition of this theory is given by Edmund Weiss in the *Astronomische Nachrichten* for 1868.

"Through friction with the air molecules, the glowing surface portions of the meteor are torn off, and in a degree proportionate to the friction. Through this cause alone the more rapid meteors would be destroyed more quickly than the slow ones; the circumstance must also be considered that they begin to glow at considerable heights because their velocity also needs to acquire a smaller retardation in order to furnish the kinetic energy necessary for incandescence. Therefore the more rapid meteors appear and disappear at greater heights than the slower ones; they draw more prominent trains after them, and besides shine much more brightly because not only do they possess a greater amount of kinetic energy but the same also in the same path, but on account of the more rapid motion, it is consumed in a shorter time. Thus the puzzling phenomenon that the brightest meteors are generally the most distant finds a simple explanation."

Other statements of the incandescence theory in various forms are made by Agnes Clerke (1885), Plassmann and Foerster (1890), More (1897), Hinders (1899), Häpke (1901), Del Pulgar (1904), and Denning (1913). Schmidt also states that meteor trains are due to products of combustion of meteor nuclei. Perhaps the widest divergence among these investigators from the views expressed in the quotations above is that of Foerster, who believed that trains consist of entirely disintegrated meteoric bodies and persistently glowing solid

particles, and incandescent gases enclosed in meteors under pressure and released by the incandescence of the nucleus and its gradual disintegration. Häpke may also be quoted as saying that

"Such strangers (the meteors) most generally consist of silica together with FeS and FeNi and are surrounded by a layer of gas which catches fire due to the resistance of the air, shines brightly over broad stretches of country and generally ends with an explosion."

There are several objections to these explanations. The meteor train often extends over several cubic miles of space, the particles of which it is composed would scarcely remain at the temperature of incandescence for over 30 minutes, probably not more than a few seconds, especially when distributed through a volume of such great extent. Moreover, if the luminosity of the train is due to heat alone, one would expect that the train would change to a deep red color before it vanished. On the contrary it appears at the last like a white mist. The red sparks and embers thrown off by a slow-moving fireball are incandescent; but these sparks and embers generally die out in a few seconds.

5. The Phosphorescence Hypothesis.

This explanation has been advanced apparently because of the phosphorescent appearance of the luminous train. The behavior of phosphorescence at normal and low temperatures, however, seems to be contrary to the supposition that the cooling particles of meteoric matter should themselves show phosphorescent light. The theory in this form is vague, and has been stated in indefinite form by A. S. Herschel, W. K. Davis and numerous other writers. If however, we consider a gas phosphorescence in the air near the meteor, we find considerable experimental evidence, as will be shown in a later section.

6. The Electric Hypothesis.

Many astronomers consider that the train of a meteor is partly, at least, composed of dust-like particles of matter in the form of a cloud. The fact that these particles appear to spread out laterally for many minutes after the meteor has passed, suggests that an electrical repulsion between the particles takes place, which produces the widening of the train. If this is the case, then some explanation is necessary to account for the electrical charge on these particles. The most plausible one seems to be that the meteor by friction on the atmosphere in its rapid flight of 30 to 40 miles per second, becomes highly charged with electricity which is immediately distributed upon the train, the corresponding charge of the opposite kind being given to the air surrounding the train.

The luminosity of the train is then explained as a brush discharge taking place between the train and the atmosphere. A known phenomenon similar to the one suggested to account for the luminous

meteor train is globe lighting or St. Elmo's fire, which is generally conceded to be due to a brush discharge and is said sometimes to last for ten seconds.

A slightly different form of the electrical hypothesis was advanced by Charlier and Hildebrandsson in an article published in Stockholm in 1875, in which they considered the electrical discharges to be due to sudden changes in temperature. On the other hand, Cornu in Volume 17 of *Sirius*, 1889, says:

"The illumination of the path of the meteor in the upper layers of the atmosphere may be attributed to a development or a discharge of static electricity without an appreciable rise in temperature . . . This kind of conception would also be in agreement with the spectrum observations which have been made on meteors, and would support the idea of those physicists and astronomers who are inclined to consider a certain number of cosmic phenomena, (aurorae, zodiacal lights, comets, solar prominences, etc.) as electric phenomena very similar to those which are easily produced in rarefied gases."

Another hypothesis advanced by G. A. Brown in *Nature*, 1905, states that the meteors which, being made of metal, are conductors of electricity, enter the earth's magnetic field and cut the lines of force at a high velocity. A high electric potential is thus generated, the energy being dissipated in heat which may raise the meteor to incandescence. In the same periodical this theory is criticized, the fact being pointed out that the earth's field is too weak to create the high voltages required by the theory to heat the meteor nucleus to incandescence, but that this might well be the case for the vaporous train. The critic further states that these currents continue to evince themselves by means of glow discharges in the gas.

The electrical hypothesis in general requires that a meteor in its flight must produce a great quantity of electricity. At present there is no ground for this assumption. Another objection to this theory is the length of time that the meteor train appears luminous. Professor Barnard has shown that a train visible to the naked eye for 15 minutes would be visible three or four times as long in the telescope. There are also many instances where trains have been visible to the naked eye for 40 minutes or more. It is difficult to suppose that a brush discharge in a cloud in the air would last for nearly an hour. Yet it is highly probable that electrical effects are produced by the great velocity of the meteor and the physical and chemical changes that accompany its combustion in the atmosphere.

7. The Reflection Hypothesis

The theory was suggested by Olmsted in 1833 that the luminosity of the meteor trains is due to reflection of moonlight and in some cases sunlight by the cloud of particles of which the meteor train is composed. This theory was also advanced by Matthiessen in 1871 and

suggested more or less definitely by many others. By a study of the observations made on meteor trains, and by simple calculations, it has been found by Professor Trowbridge that a number of persistent trains of a very pronounced type, lasting for nearly an hour, have been observed when direct light from the sun or the moon could not have reached them. The observation of line and band spectra for meteor trains also disproves the reflection hypothesis.

8. Meteor Trains an Afterglow Phenomenon.

Professor Trowbridge has suggested in his papers on this subject that meteor trains are an afterglow phenomenon in a rarefied gas which has been ionized by heat or by the passage of an electric discharge. His conclusions have been based on a study of the observations of the various astronomers who have noted the appearance and characteristics of these phenomena, and on his experimental researches on the nature of the phosphorescent afterglow in nitrogen, carried out in the Physical Laboratory at Columbia University. Probably the only previous mention of *rarefied gases* as an important feature for the production of meteor trains is the allusion of Cornu (quoted above) to discharges in rarefied gases, and the interesting, if not entirely relevant suggestion by Newalls (1897), that *nebulae* may be caused by a pressure glow in a rarefied gas.

In the paper entitled "The Duration of the Afterglow produced by the Electrodeless Ring Discharge," Professor Trowbridge has pointed out certain striking resemblances between the characteristics of meteor trains and those of the afterglow. Both of these phenomena appear between definite limits of gas pressure. The diffusion of the afterglow takes place at the same rate as the outward diffusion of meteor trains, namely, several hundred feet per minute. Like the afterglow, meteor trains often fade first in the center, showing definitely that heat could not be the only factor concerned in their production. Meteor trains undoubtedly persist at extremely low temperatures and it has been found by Professor Trowbridge that the afterglow, if produced at a somewhat higher temperature, can persist at the temperature of liquid air. The color of meteor trains and of the afterglow is usually the same, namely yellow or pale green, appearing white when faint. In a paper entitled "Spectra of Trains," to appear in the Proceedings of The National Academy of Sciences, and edited by the present writer, it is shown that the spectrum of meteor trains is in all probability that of the afterglow in nitrogen or helium, and not a metallic spectrum as some observers have contended.

All of these coincidences make it extremely probable that this explanation of meteor trains is a close approximation to the truth. It seems reasonable to believe that the heat produced by the great velocity of the meteor nucleus causes a discharge of electrons from the heated body, thus ionizing the surrounding air which becomes the seat of electrical discharge great enough to cause an afterglow similar to that

following the electrodeless discharge. In the preceding discussion it has been shown that the phosphorescence and electrical hypotheses as stated are extremely vague. The incandescence theory is impossible on acount of the long duration of the phenomenon. The reflection and chemical theories have been disproved by observation and experiment. The theory advanced by Professor Trowbridge, on the other hand, correlates most beautifully astronomical observations and physical experiments.

9. Bibliography.

As stated at the beginning of this paper, there are very few articles devoted primarily to meteor trains, but the observations which have been made and the theories put forth, the most important of which are outlined above, are contained in articles relating to the meteors themselves. A chronological list of the most important papers is given below and contains an account or outline of a theoretical discussion of meteor trains together with a statement regarding the nature of the theory advanced.

1733—John Frederick Weideler and Christian Samuel Rhostio—De Lucido Singulari a 1731 M. Octobri conspecto qua Observationes Madritensis et Vitembergensis inter se comparantur.
Meteor trains are a residuum of the aurora, blown by the wind from the north into the west.

1764—Johann Silberschlag—Theorie der am 23 Juli 1762 erschienenen Feuer Kugel.
Chemical Theory. Action similar to the reaction of water with sulphur and phosphorus respectively.

1839—Bessel—"Uber Sternschnuppen—Astron. Nach. No. 380, 381, Vol. 16, pp. 520-531.
Train due to re-illumination of meteor.

1852—J. F. J. Schmidt—Resultate aus zehnjährigen Beobachtungen uber Sternschnuppen.
The meteor train is not a subjective phenomenon, but is something distinct from the meteor nucleus. The presence of a train is only indirectly connected with the speed of the nucleus. The train is the residuum of the whole or part of the meteor disintegrated by combustion. (Incandescence theory.)

1856—Baden-Powell—Report on Observations of Luminous Meteors, 1855-1856. Report of the British Association for the Advancement of Science, 1856.
Extract from letter by Lowe proposing incandescence theory.

1868—Edmund Weiss—Beiträge zur kenntniss der Sternschnuppen. Astronomische Nachrichten Vol. 72, No. 1711, 1868.
Incandescence theory. Through friction with air parts of glowing meteors are torn off, depending on speed.

1868—Secchi—Le Stelle Cadenti del 14 Novembre 1868.
Roma Bull. Meteorol. VII, pp. 91-92.
Meteor trains contain sodium and magnesium (spectrum observations).

1871—L. Matthiessen—Beobachtungen und Positionsbestimmungen des Meteors vom 27 September 1870.
Astronomische Nachrichten Vol. 77, No. 1845, 1846, pp. 321-342.
Incandescence theory. Meteor disintegrated while glowing. Illuminated by sun for a long time after period of self luminosity. Reflection theory.

Schiaparelli—Entwurf einer astronomischen Theorie der Sternschnuppen.
Meteor disintegrated by the heat produced by friction.

1874—N. von Konkoly—Sternschnuppenbeobachtungen mittelst des Spectroscopes angestellt auf der Sternwarte zu O-Gyalla in Ungarn.
Astronomische Nachrichten Vol. 82, pp. 151-154.
Meteor trains have spectrum of metals. (Chemical theory).

N. von Konkoly—Spectroscopische Beobachtungen der Sternschnuppen des August-Schwarmes, 1875.
Astronomische Nachrichten, Vol. 84, No. 2014, p. 337.
Meteor trains contain sodium, magnesium, strontium, and lithium, on the basis of spectroscopic observations. (Chemical theory).

Die Kometen.
Sirius—Zeitschrift für populäre Astronomie, Vol. I, 1874, page 31-41.
Incandescence hypothesis.

1875—C. V. L. Charlier and H. H. Hildebrandsson
Om meteoma och meteoriten, Stockholm, 1875, in "Meteors and Shooting Stars," No. 6.
Meteor train due to electrical discharge in the atmosphere.

1877—W. F. Denning—Observations of Shooting Stars.
Color and velocity of meteor correlated with presence of train.

H. Bornitz—Kometenartige Meteore.
Sirius, 29, pp. 9-17, 1901
Theory of Nordenskiöld—Train composed of combustible or luminous materials accompanying meteor.

1879—N. von Konkoly—Beobachtungen angestellt am Astrophysikalischen Observatorium in O-Gyalla, Vol. 1, 1879, page 29.
Whenever a train accompanies a meteor the meteor nucleus has a gas spectrum. Train contains Na, Mg, Fe, Cu, C compounds, K, Li, Sr.

1885—Agnes M. Clerke—History of Astronomy in the 19th Century.
Velocity of meteors the cause of the relative brightness of the trains.

1886—Meydenbauer—Drei Meteorbeobachtungen.
Sirius, Vol. 14, pp. 271-272
Incandescence and chemical theories.

1889—Minary—Comptes Rendus, Vol. 108, p. 340
Meteor train not due entirely to production of heat.

Cornu—Uber das Leuchten der Sternschnuppen.
Sirius, Vol. 17, 1889, pp. 163-164.
Meteor trains due to a discharge of static electricity.

1890—Wilhelm Foerster—Die leuchtenden Schweife, Ringe und Wolken.
Sirius, Vol. 18, pp. 225-229, 1890.
Trains consist of entirely disintegrated meteoric bodies and persistently glowing solid particles and incandescent gases enclosed in the meteors under pressure and released by the incandescence of the nucleus and its gradual disintegration.

Joseph Plassmann—Meteore und Feuerkugeln.
Incandescent theory.

1897—W. P. More—Some Speculations in Regard to the Meteoric Matter in Space and its relations to Comets and Fixed Stars.
Incandescent theory.

H. W. Newalls—On the Luminosity Attending the Compression of Certain Rarefied Gases.
Proc. Cambridge Phil. Soc. 9, pp. 295-302.
Nebulae may be a pressure glow phenomenon in a gas.

1899—M. C. André—Comptes Rendus, August 21, 1899.
Incandescent theory.

Carl Hendersen—Ein merkwürdiges Meteor.
Sirius, Vol. 27, p. 251, 1899.
Train composed of cosmic dust or else the residuum of an exploded meteor.

1901—L. Häpke—Das Meteor vom 16. December 1900.
Incandescent theory. Meteor surrounded by layer of gas which catches fire due to air resistance.

1904—J. A. Perez del Pulgar—Bolide Extraordinaire.
Bulletin de la Société Astronomique de France, 18, pp. 136-139
Incandescence and electrical theories.

1905—G. A. Brown—Incandescence of Meteors.
Various electrical theories proposed and discussed.
1909—Flammarion—Bulletin de la Société Astronomique de France, 23, pp. 154-155. 1909.
Trains consist of a portion of the material which has been left behind. There is a definite layer of the atmosphere between 80 and 100 kilometers high, especially favorable for the production of luminosity.
1913—W. F. Denning—Meteoric Streaks and Velocities of Upper Air Currents. Symon's Meteorological Magazine, No. 566, Vol. 48, March 1913.
Incandescence theory.

In numerous other papers, theories of meteor trains are hinted at or referred to, but the articles mentioned above are the principal ones in which a more or less definite statement of an hypothesis is made.

NOTE ON PROFESSOR TROWBRIDGE'S CONTRIBUTIONS TO OUR KNOWLEDGE OF METEOR TRAINS.

Professor Trowbridge's work on meteor trains covered many years and embraced many phases of the subject. First of all, he compiled a chronological catalogue of meteor trains, consisting of detailed descriptions, references, drawings and photographs. There is also an extensive card catalogue containing a classified summary of the contents of this larger catalogue. The meteor trains have been numbered for reference in the order in which they were classified, but both catalogues are chronologically arranged. They contain information regarding the date, hour, observers, place, description of meteor nucleus and train, shape, color, height, diffusion, drift, spectra, angle of descent, velocity, duration, theoretical considerations and other matters of interest. There are also catalogues containing information relating to these various subdivisons, but some of these are incomplete and further data can be found in the main catalogue as well as in the various articles on meteors which have not as yet been classified. There are catalogues of this nature on height, color, diffusion, and drift, including several tables on these subjects which were computed for Professor Trowbridge by Mr. W. F. Denning, the noted British astronomer. The most complete catalogues are those on spectra and on theories. Accompanying the former of these are several drawings and photographs of meteor train spectra. In addition there is some information regarding the aurora and the auroral glow, especially with reference to the meteor train zone in the atmosphere. And there is a brief catalogue of observations relating to the auroral focus and auroral streamers.

The purpose of his investigations was to determine the nature of the luminous trains from astronomical observations and physical experiments. An experimental research was carried out on the subject of the nature and properties of the phosphorescent afterglow in air and nitrogen and these characteristics were found to agree to a remarkable extent with the properties of the meteor trains. A special study was made of many meteor trains which had been observed by two or more

astronomers and wherever possible the height was computed, and was found in the majority of cases to be from 50 to 60 miles. A study of the drift of the trains, then, threw considerable light on the nature of air currents at that height in the atmosphere. From a consideration of many observations on double trains, he set forth the first satisfactory explanation of these phenomena. It consists in the hypothesis that double meteor trains are due to a projection view of a tubular layer of phosphorescent gas on a cylindrical meteor train; a configuration which makes the train appear far more brilliant on the sides than in the middle. A study of the spectral observations of various astronomers as well as of the spectrum of the afterglow confirmed Professor Trowbridge's ideas concerning the identity of the two phenomena. It is thus simple to estimate the density and constituents of the atmosphere in the meteor train zone.

These results do not by any means exhaust the subject. For example, there is a very large unexplored field regarding the connection between air currents at high altitudes and barometric pressure at the surface of the earth, the study of which was commenced by Professor Trowbridge on the basis of the drift of meteor trains. A consideration of the nature of the long-enduring trains in the line of further physical experimentation will probably help solve the problem of "cold light." The subjects of the auroral glow and of the meteor train zone have by no means been cleared up, and facts of great interest and value doubtless remain undisclosed. A more careful quantitative study of meteor train spectra should be made and the method of investigation extended, if practicable, to comets, nebulae and the aurora.

A list of Professor Trowbridge's writings on meteor trains follows:

"Duration of the Afterglow produced by the Electrodeless Ring Discharge"—Physical Review, October 1906.
"The Physical Nature of Meteor Trains" (Abstract) and
"On Atmospheric Currents above Fifty Miles from the Surface of the Earth" (Abstract) both in the Physical Review, June 1907.
"On Atmospheric Currents at Very Great Altitudes"—Monthly Weather Review, September 1907.
"The Physical Nature of Meteor Trains"—Astrophysical Journal, Sept. 1907.
"A Photometer for the Measurement of the Rate of Decay of Gas Phosphorescence"—Physical Review, June 1908.
"The Importance of Systematic Observations of Persistent Meteor Trains"—Observatory, November 1908.
"Measurement of the Rate of Decay of Gas Phosphorescence"—Physical Review, February 1911.
"The Origin of Luminous Meteor Trains"—Popular Science Monthly, Aug. 1911.
"Measurements with a Moving Lamp Photometer" (with W. B. Truesdell) Physical Review, October 1914.
"The Focus of Auroral Streamers on August 26, 1916"—Science, Nov. 17, 1916.

The three following abstracts have appeared in the Physical Review, (June 1918) since Profesor Trowbridge's death:

"Photograph of an Auroral Model."
"On the Observation of the Apparent Focus of Auroral Streamers."
"Meteor Train Spectra and Probable Erroneous Conclusions of the Observers."

The following papers based on the researches of Professor Trowbridge have also been prepared by the present writer since Professor Trowbridge's death:

"Meteor Train Spectra."
"Theories on the Nature of Meteor Trains."

The unpublished material on meteor trains, considerable of which is fairly well organized, could undoubtedly be used as the basis of numerous papers or of one or more volumes, by some astronomer or physicist interested in this matter. The material available in this field has not been entirely exhausted, and if the subject were pursued results of importance would doubtless be forthcoming. Professor Trowbridge considered the meteor train investigation his greatest work and made plans gradually to publish all of his data and conclusions. He frequently expressed the wish that in case he did not live to complete this work, it should be taken up and continued by others after his death.

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TWENTY-EIGHTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

(*Continued from page 482.*)

THE POSITIONS OF THE STARS.

By FRANK SCHLESINGER.

(Address of the Retiring President, read at the meeting of the Society at the Yerkes Observatory, September 8, 1922.)

The constitution of our Society, in the amended form adopted three years ago, imposes upon your president the duty of preparing an address at the close of his term of office. Happily or unhappily, no indication is laid down as to the form of this address, and as this is the first occasion of this kind, I am deprived of the guidance usually furnished by precedent. After deliberating as to the best use to be made of this opportunity, I have decided to ask you to consider with me the status and needs concerning the determination of star places, a branch of astronomy that once engrossed so large a share of the attention of astronomers but whose pursuit has of late kept pace neither with the extraordinary activity in other departments of astronomy nor with the present needs of the science.

More seriously than ever before men of science the world over are considering the advantages and disadvantages that would follow from a broad organization of all the resources available for the promotion of their particular science. We are not all agreed as yet upon the limits to which such organization should extend, but in astronomy at

least there can be no question as to the great benefits that will follow from the widest possible co-operation. These benefits are not merely on the score of avoiding unnecessary duplication. More important still is the necessity for providing for such observational material as theory and plausible hypothesis may point out as being necessary for the next advance. Earlier in the history of our science it was possible for a single individual to master astronomy in all its phases; nowadays this is less and less possible. We have become groups of specialists, and most of us must be content to take much for granted in those branches of the science that are not close to our own work. However unavoidable such specialization may be, it behooves us to keep in mind the essential unity of our science, and not to lose sight of the relation of our efforts to its larger needs. In the organization of international and national societies, much emphasis has been laid upon the necessity for bringing together men who are working along similar lines; but a more important function of such societies is to gather around one table, even if it be only a dining table, those whose specialties are of different character so far as form is concerned, but which are, or should be, related in their aims and bearings. It is from a similar point of view that I wish to call your attention to the state of affairs regarding the determination of star places. I must begin by briefly outlining some of the problems that depend upon knowledge of this kind.

The positions of the stars themselves are only of minor importance; they have, it is true, been required in the past for the purposes of navigation, and also to serve as reference points for moving objects like planets and comets. But now the former of these applications has disappeared, and the latter has sunk into unimportance in the face of the deductions concerning the structure of the universe that have been made and can be made from the studies of the *changes* in star positions. The possibility of such changes was suspected twenty centuries ago by Hipparchus and was doubtless one of the strongest reasons that led him to compile the first star catalogue. But the actual proof of the existence of such motions is only two centuries old and is due to Halley. It is curious that this discovery was not made earlier. For example, among the stars catalogued in common by Hipparchus (about 150 B. C.) and by Tycho Brahe (about 1580) there are a considerable number whose motions exceed one second of arc a year, and which, therefore, must have changed their places in the seventeen intervening centuries by at least the apparent diameter of the moon, a quantity very much in excess of the inaccuracy of either of these great catalogues, as well as of certain intermediate ones. Halley's discovery remained a detached fact for nearly another century until William Herschel showed from the consideration of only seven stars that proper motions are partly due to the motion of our own sun. This result was in due time tested by many studies of far greater numbers of

stars. Up to within about twenty-five years ago, the accepted view among astronomers was that, if we regard the entirety of stars as being on the average at rest, then the motions of individual stars are completely haphazard. In 1897 Kobold pointed out that this simple hypothesis is not adequate to explain the observed facts. In 1904 at the International Congress held at St. Louis, Kapteyn read a truly epoch-making paper in which he showed that observed proper motions pointed to the existence of two groups of stars instead of one; and that while within each group the motions are entirely haphazard, the groups themselves have a relative velocity of about forty kilometers a second. These two groups do not seem to be separated in space but are thoroughly intermingled, so that in general it is only the direction of a star's motion and not its location that indicates to which of the groups (or drifts or streams as they are now variously termed) any particular star must be assigned.

Shortly after the appearance of Kapteyn's memorable paper, Schwarzschild showed that the proper motions could be accounted for by an alternative hypothesis as well as by two drifts; namely, that the stars after all form a single group but that the motions within it are more commonly parallel to a certain straight line (or preferential axis) than at right angles to it, with intermediate frequencies for intermediate angles. Such a distribution of motions is described as *ellipsoidal*. Perhaps in the whole domain of physical science there is no question of greater philosophical importance than to inquire which of these two explanations really applies. The earlier or two-drift hypothesis divides the stars into two separate entities and makes the term "universe" something of a misnomer, while the ellipsoidal hypothesis has the advantage of simplicity, merely introducing as it does a new characteristic of the motions of stars.

The only feasible way to distinguish between these two hypotheses is to study the distribution of the frequencies with which occur motions parallel to the longest axis in the ellipsoidal explanation or (what is the same thing) parallel to the direction of relative motion between the two drifts. Unfortunately the two theoretical distributions are not very different, and it turns out that the proper motions now at our disposal are not sufficiently numerous to enable us to distinguish between them. The great need in this and other connections is the determination of the proper motions of many additional stars. We do not need very accurate proper motions for this particular purpose, and it would not help much if we were merely able to increase the accuracy of proper motions already within our knowledge without considerably increasing their number. The reason is that the residual motions of individual stars (after allowing for the drift or the preferential motion and of course for the effect of the solar motion) are of the same order of size as the systematic motions; hence the effect of a reasonably small degree of inaccuracy in our proper motions is apparently to increase a little the amount of these residual motions.

Neither the two-drift nor the ellipsoidal hypothesis accounts completely for all the systematic tendencies in proper motions that have been detected. Some of the outstanding phenomena seem to indicate the existence of a third drift, but even with this addition some discrepancy still remains. Here again the crying need is for many more proper motions.

Closely allied to the phenomenon of star streaming is that presented by moving clusters. The best example of these is the one in Taurus, discovered by Boss in 1908. About ninety stars scattered throughout the constellation and embracing an area of 300 square degrees have been found to be moving almost precisely parallel to each other, so that their projected motions on the celestial sphere seem to converge to a single point. This point is very near the direction of one of Kapteyn's great star drifts, and there can be little doubt that the Taurus cluster is related in some fundamental way to the drift. There is, however, one essential difference between the two; the direction of the drift is inferred from the mean of many motions, only a few of which really coincide with this mean; while in the Taurus cluster the motions are almost precisely the same, and would probably agree still better if we could get rid of accidental errors in our tables of proper motions.

The detection of this cluster has led to a general examination of proper motions to see whether there may not be other groups of the same kind. Two additional ones certainly exist, several others await better data before their reality can be proved. It is, however, all but certain that there are a great many of these clusters. For, in the present state of our knowledge, their existence can be proved or even suspected only if their apparent motions are large; otherwise accidental errors bear so high a ratio to the true motions as to mask their equalities. It is not at all impossible that group motions such as we are discussing may apply to the great majority of stars, instead of to a few. And even the great star streams themselves may ultimately be found to consist of aggregations of moving clusters, within which the motions are sensibly parallel, but with some differences in direction and amount as we go from cluster to cluster. But it will probably be a long time before we can hope to test inquiries of this kind, for they call for not merely many proper motions but highly accurate ones. Doubtless the determination of radial velocities will play a leading part in future researches in this subject.

There is probably no real distinction between wide-spread moving clusters and the more compact clusters of which the Pleiades and Praesepe are the best examples. It is known that the projected motions in these clusters are sensibly parallel; the extent of these clusters, however, is so small that the point toward which they may be converging can be definitely determined only when we know the proper motions with an accuracy far in advance of what is now the case.

Recently very distant companions to certain bright and rapidly

moving stars have been discovered. Thus Alpha Centauri, itself a binary of wide separation, has a faint companion more than 2° distant which shares its large proper motion in amount and direction. That we are not dealing with a mere coincidence was shown by the determination of the parallax of this companion; it comes out like that of Alpha Centauri itself, about three quarters of a second. But we can hardly say that there is any physical relation between these bodies in the sense that they form a dynamical system. The mass of this binary is closely known and would imply a period of revolution for the distant companion amounting to several million years. About a score of similar cases have been detected, and we may confidently expect that their number will be greatly increased in the future; for here again, the present state of our knowledge permits us to detect these distant companions only in the case of rapidly moving objects. It is indeed probable that many of the double stars described as "fixed" (pairs that seem to have maintained their relative positions practically unaltered during the greater part or all of a century), do not differ in any essential from systems like Alpha Centauri. If the latter were removed to forty times its present distance from us it would appear to be a close pair of eighth magnitude stars with a very faint fixed companion at a distance of 3′ sharing the proper motion of 0″.1 a year. Many counterparts to such a system can be found in our lists of double stars.

It appears then to be very possible that, beginning with certain fixed pairs having common proper motion, and going through pairs like Alpha Centauri or Capella, clusters like the Pleiades and Praesepe, clusters like that in Taurus, and finally ending with the star streams, we have a series of phenomena which merge into each other by insensible steps.

This brief survey is very far indeed from presenting all the problems that a knowledge of proper motions will help to solve. I have only aimed at giving some indication of how pressing is the need for extensive data of this kind. Let us now turn to the other side of this matter and see what is actually at our disposal. Up to the present time observers with the meridian circle and closely related instruments, have published nearly 500 catalogues containing about 1,250,000 star positions. These relate (allowance being made for duplicates) to about 300,000 different stars. In contemplating this enormous mass of data our chief impression is one of deep admiration for the self-sacrificing devotion to their science on the part of these observers. It must be remembered that nearly all this painstaking work preceded the developments we have just referred to, and was undertaken only because on general principles such observations seemed likely to lead to important increases in our knowledge of the universe; and in every case these catalogues were compiled with the full knowledge that they should find their use and application only after the observer had passed away. Our next impression is not so pleasant; we cannot help being

struck by the heterogeneity of the results and by the lack of any general plan. It is easy to see and to say that this is so at this late day, and it would indeed be wonderful if all the progress of recent years should have failed to indicate notable improvements in this department of the science, as it has in every other.

The amount of time that astronomers have had to spend in searching through old star catalogues and in discussing their errors is truly appalling. Many attempts have been made to save some of this waste effort, Lewis Boss and Auwers especially having devoted the best part of their lives and of their great talents to this wearisome work. They have independently gone through all the old material, completely and once for all, and have set down their best judgment as to the extent of both accidental and systematic errors of all these numerous compilations of star places. Even with these great helps the computation of the proper motions of only a few stars makes a formidable task, chiefly on account of the labor of collecting the old observations. About twenty-five years ago, Yale Observatory began to compile an Index to the positions of all stars north of 22° south declination; this shows at once for any particular star where to find early positions and saves a great deal of drudgery. It has not been feasible to publish this Index, but astronomers have made liberal use of it by correspondence, and the observatory continues to offer to copy out of the Index information concerning specific lists of stars. But a much better aid of the same kind will soon be available. Shortly after the Yale Index was begun the Prussian Academy of Sciences proposed to compile a somewhat similar index; this undertaking grew into magnificent proportions but the war and other causes have since somewhat curtailed it. Their plan now is to collect into one set of volumes all the star places published before 1900 and all reduced to one date (1875) by the use of the same constants and methods throughout. Just a few weeks ago the first volume of this index came to our desks. It includes all stars north of the equator in the first hour of right ascension, and thus covers only one forty-eighth of the sky. At least ten years will elapse before the completion of the northern hemisphere alone. These volumes, together with the weights and systematic errors published by Boss and by Auwers, will put this subject on a new footing and will doubtless induce the computation of additional proper motions.

Assuming then that we have at our disposal all the helps that may be necessary to bring the computations within reasonable dimensions, how many accurate proper motions can we hope to extract from the material at hand? This is the question that Boss set out to answer many years ago. As a result of an exhaustive examination he published in 1910 a Preliminary General Catalogue of 6188 stars. This includes all the stars which had been observed accurately enough and often enough to furnish reliable proper motions. In the dozen years that have elapsed since the publication of this catalogue, additional observa-

tions made at San Luis, Greenwich, Cincinnati and elsewhere have brought other stars into this class; but unless we are willing to stretch a good deal our definition of what constitutes an accurate proper motion, the most that we can expect is that the next twenty years will about double the number of proper motions contained in the Preliminary General Catalogue.

As this increased number falls far short of what is demanded for the solution of some of the problems indicated above, it behooves astronomers to concern themselves at once with the ways and means for greatly extending knowledge of this kind. The foundations for such extension already exist in the Gesellschaft Catalogue and in the great Astrographic Catalogue. The former of these is based upon observations made in general about forty years ago, through the co-operation of a score of observatories in Europe and in America. They include all stars down to the ninth magnitude on the Durchmusterung scale, as well as some fainter ones. The northern half of this undertaking (from 2° south declination to 80° north) is now completely published. It contains the positions of 120,000 stars observed on the average of 2.8 times. The precision of the observations is such that the probable error of one catalogue place averages 0″.40 in right ascension, and 0.″36 in declination. The southern continuation of this catalogue has only partially been published; indeed, parts of the southern sky have not yet been provided for. What observations have been made for stars south of the equator are of much more recent date.

It appears to the writer that the re-observation of all the stars in the Gesellschaft Catalogue and the continuation of similar catalogues to the south pole of the heavens constitute one of the most pressing needs of astronomy today and should be carried out with as little delay as possible.

Such a plan as this is one that can easily be realized with present-day methods; it is well within the capabilities of a few observatories, or even of one observatory, to carry it out promptly. On earlier occasions I have reported to this Society the results of a series of experiments on the determination of star places by means of wide-angle doublet cameras. These experiments (the detailed account of which has long been in press) show that such cameras are well suited for such work. As compared with the earlier visual methods by which such positions have hitherto been compiled, there is at least a twofold gain in accuracy, the probable error from a single photograph coming out equal to 0″.2. The gain on the score of economy of effort is much greater, so that it is no exaggeration to say that a hemisphere could be covered by such methods with as little labor as was required to cover some of the single zones in the Gesellschaft Catalogue itself.

The prosecution of this re-observation of the Gesellschaft stars would put us into immediate possession of more than 100,000 proper motions of fair accuracy, as the average probable error of one deter-

mination should be under 0".01. These doubtless will be competent to answer some of the more pressing questions concerning star streaming, but, as we have indicated, they will not help us much with others of these problems. I venture to guess that fully 100,000 highly accurate proper motions are required to settle the problems that are at present urgent, to say nothing of the additional developments that the immediate future is likely to reveal. As in almost every other department of astronomy, our knowledge in this shows a one-sided distribution, the northern hemisphere being several times as rich in proper motions (both actually and potentially) as the southern. These considerations emphasize all the more strongly the necessity for covering the whole sky in the way proposed. In some parts of the southern hemisphere these positions will constitute the first accurate determinations for the fainter stars, and in all parts of the sky, north as well as south, they will constitute the most accurate positions that have thus far been deduced for the great majority of stars. We owe it to our successors to take immediate advantage of newer and more accurate methods, and in each age to set down as accurate positions of the stars as our means permit. In doing this we shall merely be passing on the legacy bequeathed to us by the observers of the nineteenth century.

The re-observation of the Gesellschaft stars would seem to be highly desirable from still another point of view, namely that of the Astrographic Catalogue. The plates that form the basis for this great undertaking cover an area of four square degrees. To deduce the constants of these plates it was originally planned to observe with the meridian circle two sets of stars; first the "intermediary" stars, about one to every region two degrees square; or more than 10,000 for the whole sky. Second, upon these positions it was proposed to refer those of a far greater number of *étoiles de repère* or comparison stars. If the proposed programme with the doublet is carried out it will be unnecessary to observe these numerous *étoiles de repère,* since a combination of the doublet places with those in the Gesellschaft Catalogue will in general serve very well to reduce the astrographic plates, each of which will on the average contain about a score of Gesellschaft stars.

The completion of such a programme as this will provide us with ample material down to about the tenth photographic magnitude. For some important purposes we should know the proper motions of fainter stars. This is one of the objects of the Plan of Selected Areas, in which it is proposed to compare photographs separated by a long interval of time. This method has the advantage of being very expeditious, but the motions thus deduced are only relative. The writer is strongly of opinion that it is desirable to set down now the absolute positions of faint stars in these areas for future reference, as well as to carry out the differential observations.

A simple way to extend our knowledge to stars two or more magnitudes fainter than those in the Gesellschaft list was suggested by the

writer several years ago in connection with the determination of parallaxes. He recommended that in those cases where the proper motion of the parallax star is well determined two or three plates of each parallax region be secured about ten years after the parallax series itself had been completed. The measurement of these plates will again yield relative proper motions, but in this case they can at once be transformed into absolute motions with the use of the known motion of the parallax star. This plan has the advantage of yielding results that are free from magnitude error, since on such plates the parallax star has been equated (in apparent magnitude) with the comparison stars by means of an occulting sector. The probable error of such determinations of proper motion will be about 0″.002.

In a paper that appeared only a few weeks before his death, Kapteyn makes the same recommendation, but from a somewhat different and more important point of view. He begins by saying: "I know of no more depressing thing in the whole domain of Astronomy, than to pass from the consideration of the accidental errors of our star-places to that of their systematic errors. Whereas many of our meridian instruments are so perfect that by a single observation they determine the co-ordinates of an equatorial star with a probable error not exceeding 0″.2 or 0″.3, the best result to be obtained from a thousand observations at all of our best observatories together may have a real error of half a second of arc and more." He then goes on to show that our accepted systems of proper motions in declination are undoubtedly affected by large systematic error, amounting perhaps to 0″.015 per annum. Among other things he shows that the presence of this error causes the determinations of the sun's apex to be at fault by an amount that increases as the proper motions of our reference stars decrease in size. He therefore proposes to reverse the process and to determine absolute proper motions free from systematic error on the assumption that stars of all degrees of motion should yield the same indications for the position of the sun's apex and for the vertices of the two streams.

It may be worth while to mention here an entirely independent way in which light can be thrown on systematic errors in proper motion. Observations for latitude by Talcott's method have now reached a high degree of precision; the probable error for one observation is generally not greater than 0″.1 and in some cases it is considerably less. As one thousand or more observations are secured each year at a latitude station, it is obvious that the lapse of only a few years will be sufficient to determine the average proper motions of the stars employed, providing we can assume that the latitude of the station is not changing progressively. Recent developments indicate that it would be hazardous to make this assumption if only one station is concerned, but the discussion of the results from many stations would undoubtedly give us valuable information as to our systems of proper motions.

Thus far practically all our knowledge of the absolute positions of

stars has been derived through the use of one type of instrument, namely the meridian circle. Some of the best minds of each generation of astronomers have studied this instrument, and few machines of human devising have reached so high a degree of perfection. In our own times we have seen such important improvements as the introduction of the transit micrometer, the use of Gill's form of meridian mark, and the practise of observing with the instrument as far as possible in the open air. Though the degree of perfection attained is high, it is desirable on obvious grounds that some radically different instrument be developed for securing absolute positions. In spite of the well-recognized advantages that photography would have for such an application, and its far greater freedom from personal equation in all its forms, no serious attempt has as yet been made to build a camera for the determination of absolute places, along lines that differ materially from those of standard visual instruments. This appears to be a difficult problem, but it is one of the highest importance and any promising effort to solve it deserves our hearty and substantial encouragement. It is of course highly desirable that a new method or a new instrument should exceed in accuracy those in present use; but in the case under consideration this is not absolutely necessary. If we should find that we could perfect a new method for determining absolute positions only so far as to yield places of the same order of accuracy as that which the meridian circle affords, it would still be very valuable, as a comparison of the two sets of results would doubtless throw light upon the nature of the systematic errors of both.

A survey of the present status of the determination of star places cannot fail to impress us with the enormous amount of work that must be done in the not too distant future. But there seems to be no way of avoiding this great task and it will not be avoided. While it would be dangerous to predict just what the course of events will be, we may be sure that astronomers of our own day will fulfill in some way the obligations imposed upon them by the needs of their science, as fully and as unselfishly as have their predecessors.

ABSTRACTS OF PAPERS

SPECTROSCOPIC PARALLAXES OF A-TYPE STARS.

By W. S. Adams and A. H. Joy.

On account of the large proportion of stars which fall in spectral Class A it is especially desirable that some method should be found by which the spectrum can be utilized for the determination of the absolute magnitudes and parallaxes of such stars as well as of those of the later types.

The difficulties in applying the methods developed previously for stars of types F to M are not only such as arise from the nature of

the early type spectrum itself but from the small spread of the absolute magnitudes and the lack of accurately known parallaxes upon which the study can be based. In the last few years the latter difficulty has been overcome to a considerable extent. Parallax observers have been giving more attention to these stars and many trigonometric parallaxes have been determined. In addition studies of moving groups of stars have resulted in accurate values for the distances of these groups in which many A-type stars as well as those of later types are found.

Several years ago an examination of the spectrograms of a chosen list of early type stars, which were secured with the sixty-inch reflector and higher dispersion than is oridinarily used, made it clear that, except for a few exceptional stars such as α Cygni and the faint companion to o^2 Eridani, none of the spectral lines appeared to show change of intensity with varying absolute magnitude of a character adapted for such a purpose. Further study made it apparent that an accurate classification of the stars according to spectral type would necessarily be the first step in the work. Since the K line of calcium does not show on most of the spectrograms, the spectral types were determined on the Harvard system largely from the strength of the metallic lines.

More recently in comparing the spectra of the A-type members of groups whose parallaxes are most accurately determined it was found that, if the stars are divided into two classes depending on the sharpness of their spectral lines and then arranged according to type, a definite correlation appears between spectral type and absolute magnitude—the earlier type corresponding to greater intrinsic brightness. For a given type stars with sharp lines are brighter than those with diffuse lines. Sharp lines have long been recognized as being characteristic of stars of high luminosity. This division also aids greatly in the classification of these stars where there is such a diversity in the character of the spectral lines. Spectrograms of nearly all the early type stars which are known to belong to the Taurus and Ursa Major groups have been secured and classified as accurately as possible. A comparison of the types and absolute magnitudes shows very definitely that for a given type there is practically no range of variation in the absolute magnitudes within the sharp or diffuse divisions. Thus it appears possible to neglect the individual lines of the spectrum except as they affect the classification and by constructing proper curves to determine the absolute magnitude simply from the type and character of the lines.

The study has been then extended to include all A-type stars for which the parallaxes have been well determined. The same correlation is found and, using 104 trigonometric and 56 group parallaxes, curves have been drawn which give the relationship between spectral type and absolute magnitude. Many dynamical parallaxes of double stars are available but on account of the uncertainty of the mass-

factor for these stars it has been thought best not to use them in forming the curves.

The curves allow values for the absolute magnitudes to be taken out for any star if the type and line characteristics can be determined from the spectrum. The accuracy of the determination of the parallax by this method compares very favorably with the results for later-type stars by the spectroscopic method. For 82 stars belonging to the moving groups the average deviation of the parallax is only 0".0077; for 104 stars with trigonometric parallaxes 0".0131. The corresponding differences taken with regard to sign are —0".0014 and 0".0000, respectively. The method has been employed in the determination of the absolute magnitude and parallax of 544 Boss stars of types B8 to F3 for which spectrograms have been secured with the sixty-inch and one-hundred-inch reflectors. These will soon be published. Stars with spectra similar to that of α Cygni, which doubtless correspond to the pseudo-cepheids of later type, and four or five dwarfs have not been included because they seem to require separate treatment.

As a check on the applicability of the method a comparison has been made for the whole list of stars which shows the relationship between proper motion and the parallaxes obtained. The stars were divided into ten groups according to proper motion and the average parallax taken for each group. The results show the close correlation between proper motion and parallax as would be expected. It is interesting to note that a parallax of 0".009 corresponds to zero proper motion.

A PARTIAL EXPLANATION, BY WAVE-LENGTHS, OF THE K-TERM IN THE B-TYPES. II.

By Sebastian Albrecht.

At the preceding meeting of this society it was shown that recent laboratory wave-lengths for twenty oxygen and nitrogen lines occurring in B-type stars, are systematically 0.063 A longer than the adopted normals. This corresponds to a change of —4.2 km in the radial velocities derived from them. A discussion of the available portions of the data on which the K-term is based, indicated that the new wave-lengths for this one group of lines alone would reduce the K-term, which is about 4 km, by about 0.3 km for the entire B class and by about 0.8 km for classes B0 to B2.

New laboratory wave-lengths by Crookes for silicon and a new wave-length for the helium line 4713 by Merrill, then at the Bureau of Standards, still further reduce the K-term by about 1 km for the entire B class and by about 2 km for classes B0 to B2.

Moreover, the radial velocities for Class B stars possess the apparently inherent weakness that the lines upon which most emphasis has been placed, namely, carbon 4267, magnesium 4481, and the four

helium lines in the region used, are double, with unequal components, and therefore not suited for primary radial velocity work. Hγ also is not entirely satisfactory. For silicon the laboratory wave-lengths are erratic. They are susceptible to slight impurities in the samples of silicon employed. Also the spark terminals oxidize rapidly in air. At present the oxygen and nitrogen lines alone seem free from serious objection, and these would give essentially a zero K-term. Further laboratory study of the lines occurring in these stars is very much needed, especially of the silicon lines 4553, 4568 and 4575.

TRIGONOMETRIC PARALLAX OF THE PLEIADES.

By Harold L. Alden.

Forty-eight plates, taken with the twenty-six-inch McCormick refractor in three concurrent series centered at different points in the Pleiades, provide data for the determination of the parallaxes of twenty-two stars which are very probable members of the cluster. One star was measured on two series of plates so that twenty-three values of the parallax of the cluster enter into the mean derived. Eight or nine non-cluster stars of mean magnitude 10.45 were used as comparison stars for each series of plates.

The weighted means give the following:

Weight based on	Mean Relative Parallax	Probable Error
(a) Probable errors of individual parallaxes	+0″.0078	±0″.0028
(b) Equal weight for each series	+0.0083	±0.0038
(c) Unweighted mean	+0.0054	±0.0028
(d) Difference in magnitude between parallax and comparison stars	+0.0035	±0.0027

The unweighted mean of these four values is +0″.0062 for the relative parallax.

To reduce this value to absolute parallax +0″.0040 is added giving as the absolute parallax of the Pleiades Cluster +0″.0102. The probable error of this result is about ten or twenty per cent.

The mean proper motion in right ascension from the plates is +0″.030 as compared with Boss' value for twelve stars of +0″.023.

SATURN'S RINGS WHEN THE EARTH PASSED THROUGH THEIR PLANE IN 1920-1921.

By E. E. Barnard.

Saturn's rings were observed with the 12-inch and 40-inch telescopes near and during the critical period when their plane passed through the earth in 1920 and 1921. The following data are from the *American Ephemeris and Nautical Almanac.*

Before November 7, 1920, the earth and the sun were both south of

the plane of the ring. From this date until February 22, 1921, the earth was north of the plane, on the opposite side from the sun. On February 22 the earth passed again to the south side. On April 10 the sun passed to the north and left the earth on the south side until August 3, when the earth also passed to the north—the same side as the sun.

On 1920 Nov. 7, $23^h\ 40^m$ G. M. T., under good conditions and with the planet occulted, the ring was not visible with the 40-inch telescope. The seeing was as high as 3/5.

1921 Feb. 22, $20^h\ 30^m$. The ring was quite bright as a rather thin line. In moments of steadiness it was perfectly linear.

Feb. 24, $21^h\ 0^m$. The ring was bright and linear.

Apr. 7, $17^h\ 0^m$. The ring was very faint but clearly seen.

Apr. 9, $18^h\ 0^m$. Quite conspicuous with occulter.

Apr. 10, $12^h\ 40^m$. Ring distinctly visible.

Apr. 11, $12^h\ 30^m$. Seen faintly without occulter. Seeing good but sky poor.

Apr.12, $13^h\ 0^m$. Visible without occulter.

The ring, therefore, did not entirely disappear in three cases out of four when they were presented on edge to us in 1920-21. The "condensations" were seen and measured, and occupied the same positions as in 1907. They were not seen when the ring was on edge to us. They were, therefore, not raised places on the ring. They are a phenomenon due to the ring being seen obliquely from the dark side—the sun's light penetrating through the ring and illuminating the dark side by diffusion of the light among the particles composing the rings. Sometimes the "condensations" appeared round; at other times they were elongated. When seen from the dark side, the ring and condensations always appeared to shine with a soft nebulous light.

On several occasions when the earth was on the dark side of the ring the inner condensations were distinctly but closely double. Measures on June 17 made the distance between the condensations 0".76. The distance between the following limb and the outer one of the double was 3".19. This double condition was first reported in 1907 by Aitken. It was also then seen by the present observer.

ON THE CHANGE IN THE PERIOD OF THE VARIABLE STAR BAILEY NO. 33 IN THE CLUSTER M 5.

By E. E. Barnard.

At the Ann Arbor meeting of the American Astronomical Society, in September, 1919, the writer called attention to the changes in the period of this small variable star. Two more series of observations have been obtained, for the years 1920 and 1922. These seem to show a continued shortening of the period. The entire series of periods is

given in the following table, in which the last column of differences shows the change in the period.

Interval	No. of Periods	Period in Days	Period	Differences from Mean
		d	h m s	s
1899-1900	688	0.50147330	12 2 7.293	—0.002
1899-1903	2750	.50147330	7.293	— .002
1899-1904	3671	.50147314	7.279	+ .012
1899-1908	6483	.50147341	7.303	— .012
1899-1911	8792	.50147357	7.316	— .025
1899-1913	10172	.50147368	7.326	— .035
1899-1915	11566	.50147354	7.314	— .023
1899-1916	12284	.50147338	7.300	— .009
1899-1917	12992	.50147329	7.293	— .002
1899-1918	13867	.50147309	7.275	+ .016
1899-1919	14559	.50147310	7.276	+ .015
1899-1920	15267	.50147292	7.260	+ .031
1899-1922	16653	.50147291	7.260	+ .031
			Mean = 12 2 7.291	

These periods have been determined from observations of the time of equality of the light of No. 33 with a comparison star *k* close to it. They are dependent on a normal for 1899.

Equality of light with *k* can be determined to within one or two minutes of time. To show the consistency of the observations all the times of equality observed in 1922 are given in the following table. Each observation is reduced to the observation time of May 6. They are all reduced to the sun, a precaution absolutely necessary in a case of this kind. The observations are in Central Standard Time (6^h slow of G. M. T.).

Observations		Reduction to Sun	At Sun	Reduction to May 6	Reduced to May 6
	d h m	m	h m	d h m	d h m
1922 April	22 10 39.8	+7.6	10 47.4	+14 0 59.4	May 6 11 46.8
	29 11 7.9	+7.8	11 15.7	+ 7 0 29.7	45.4
May	4 11 27.6	+7.9	11 35.5	+ 2 0 8.5	44.0
	6 11 37.7	+7.9	11 45.6	0 0 0.0	45.6
	13 12 8.2	+7.8	12 16.0	— 7 0 29.7	46.3
	16 12 18.5	+7.8	12 26.3	—10 0 42.4	43.9
	20 12 37.2	+7.7	12 44.9	—14 0 59.4	45.5
				Mean = May 6 11 45.3	

This corresponds to Julian Day 2423181.4898.

Professor Turner has called attention to the probability that the comparison star *k* is itself variable through 0.2 — 0.3 magnitude. Professor Seares has probably verified the variability. If *k* is really variable, it will affect the results given here. The amount of variability, however, is very small compared with the other variables of the cluster. I believe the question of its variability is not yet definitely settled. In the meantime I am giving the results of my observations on the assumption that *k* is constant. Later, when the period of *k* is determined, the observations can be freed from its effect.

RE-DETERMINATION OF SECONDARY STANDARDS OF WAVE-LENGTH FROM THE NEW INTERNATIONAL IRON ARC.

By Keivin Burns, C. C. Kiess, and W. F. Meggers.

In order to obtain lines of constant wave-length, constant intensity distribution and adapted to high orders of interference, the International Astronomical Union has adopted the Pfund arc operated between 110 and 250 volts, with 5 amperes or less, at a length of 12 millimeters and used over a central zone at right angles to the axis of the arc not to exceed 1¼ mm in width and with an iron rod 7 mm in diameter at the upper pole. Using such an arc 80 secondary standards have been re-determined relative to cadmium and neon wave-lengths, and measurements have been made on 30 stable lines to replace unsatisfactory secondaries and fill the longer intervals. The results will be published in the *Scientific Papers of the Bureau of Standards*.

THE ORBIT OF THE SPECTROSCOPIC BINARY H. R. 6532.

By J. W. Campbell.

Of a list of eight stars whose radial velocities the writer undertook to determine in the summer of last year, two turned out to be spectroscopic binaries. The orbit of the first, H. R. 5992, was completed last year and appeared as No. 28 of Vol. I of the *Publications of the Dominion Astrophysical Observatory*. The orbit of the second, H. R. 6532 ($\alpha = 17^h\,27^m.6$, $\delta = 12^\circ\,00'$, type A0, visual magnitude 6.18), is the topic of this paper.

The binary character of this star was shown by the first two plates secured in July 1921. Through the kind coöperation of the other members of the staff 19 plates were secured last year and 14 this year, which gave a good distribution along the velocity curve. The data from these 33 plates formed the basis of the least-squares solution which resulted in the following final elements.

P =	6.7984	±0.00065 days
e =	0.069	±0.013
ω =	116°.26	±14°.13
K =	50.18	±0.91 km/sec.
γ =	−12.79	±0.62 km/sec.
T =	J. D. 2422878.154	±0.265 days
$a \sin i$ =	4,680,000 km	
$\frac{m_1^3 \sin^3 i}{(m + m_1)^2}$ =	0.0886 ⊙	

The probable error of a normal place of weight unity is ± 1.40 km/sec., and the probable error of a plate ± 2.94 km/sec. The least-squares solution reduced Σpv^2 from 90.51 to 68.85.

NOVA SCORPII NO. 3 (1922).

By Annie J. Cannon.

In July, 1922, while comparing two plates taken at Arequipa with the 1-inch Cooke lens, an image was found on a plate taken July 17, 1922, which was absent on the other plate. An examination of the earlier plates available here showed that the object was absent on five plates taken between 1909 and 1918, and that on July 1 and 3, 1922 it was also invisible and fainter than the magnitudes 12.5 and 10.8, respectively. On July 11, it was present, of magnitude 10.5. On July 12, it was of magnitude 10. Since it was suspected that it might be a nova, its spectrum was obtained with the 8-inch telescope as soon as possible on the evening of July 29. An immediate examination of the plate showed the presence of both bright and dark hydrogen, calcium, and other lines. A photograph which shows even more clearly that the spectrum is of the nova type was taken by Professor Bailey with the 24-inch Bruce telescope on July 30. Hβ, Hγ, Hδ, Hϵ, K, and Hζ, are broad bright bands accompanied by dark bands on the edges of shorter wave-length.

Photographs have since been obtained with the 1-inch, the 8-inch, and the 24-inch telescopes on July 31, August 1, and August 2. The light was diminished about 0.7 of a magnitude from the observed maximum brightness. The spectrum has shown some of the changes seen in other novae, such as the fading out of the bright band K of calcium.

Previous to discovery the spectrum had already been photographed with the 8-inch telescope on July 12, and 25, 1922. On both plates it is near the edge, where the definition is poor. No bright bands are seen on the plate of July 12, making it probable that the light was then still increasing. On the plate of July 25, the spectrum, although in poor focus, is clearly seen to be composed of bright bands of the nova type. This plate was not developed until August 4, or an earlier examination of it would have revealed the nature of the object.

This star precedes No. 24157 in the Argentine General Catalogue, 42 seconds, and is south 5′.4. Its approximate position for 1875 is R. A. $17^h\ 39^m\ 59^s$, Dec. $-36°\ 34'.0$.

MEASUREMENTS OF PLANETARY RADIATION.

By W. W. Coblentz and C. O. Lampland.

The thermal radiation emitted from a planet as a result of warming by exposure to solar radiation, including heat which may be radiated by virtue of a possible high internal temperature of the planet itself, is essentially of long wave-lengths 6 μ to 12 μ. Hence, by means of a 1-cm cell of water, interposed in the path of the total radiation

emanating from the planet, this long wave-length radiation can be separated from the reflected solar radiation, and in this manner a measurement obtained of the energy re-radiated. If there is planetary radiation, then the water cell transmission will be less than that of direct solar radiation.

It appears to be relatively unimportant whether a screen is used which is opaque to radiations longer than 1.4 μ (a water cell) or a screen which is opaque to wave-lengths greater than 4.2 μ (quartz cell). For, if there is planetary radiation, the transmission will be different from that of the direct solar rays, whatever the cell that is used.

Radiometric measurements were made on Venus, Mars, Jupiter, Saturn, and the sun, and in cases where similar measurements had been made at Mt. Hamilton, California, in 1914, the data were found in good agreement.

These measurements show an interesting sequence of water cell transmissions which decrease (i. e. the percent of planetary radiation increases) with decrease in thickness and density of the planetary atmospheres; Jupiter (69), Venus (66), Saturn (60), Mars (50), and the moon (15). The percent difference between the water cell transmission (69 percent) of the direct solar radiation and that of the radiation emanating from the planet is a measure of the planetary radiation and is as follows: Jupiter (0), Venus (5), Saturn (15), Mars (30), and the moon (80).

The water cell transmission of the total radiation emanating from Jupiter is practically the same as that of the direct solar radiation. From this it appears that the outer atmosphere of Jupiter does not radiate appreciable long wave-length, infra-red, energy as the result of warming by solar rays, and that the atmosphere is sufficiently thick and opaque to trap all the energy re-radiated as the result of warming of its interior by solar radiation, or by internal heating, if the interior of Jupiter is still highly heated.

Similarly, owing to cloudiness, the atmosphere of Venus, like that of the earth, appears to trap practically all the planetary radiation.

The water cell transmission of the radiations from the southern (50.6 percent) and northern (53.1 percent) hemispheres of Mars should be and are higher than that of the radiations emanating from the equatorial (47.3 percent) region, owing to the depletion of the re-radiated energy by the greater air mass. Moreover, the intensity of the planetary radiation from the northern hemisphere of Mars was found to be less than from the southern hemisphere. This is to be expected in view of the observed cloudiness over the northern hemisphere, which is visually the brighter, and is approaching the winter season, and hence is at a lower superficial temperature.

ON THE LIGHT VARIATIONS OF β LYRAE AND δ CEPHEI.

By Ralph H. Curtiss.

Recent observations by Stebbins and the writer show that minima of β Lyrae are deviating strongly from the epochs predicted by Pannekoek's revised formula and by that of Lehnert. A new formula, representing the newer and also the old observations satisfactorily, has been computed at Ann Arbor by Rossiter. It is given here in order that it may be immediately useful.

Time of Principal Minimum = 1855 Jan. $6^d.604$ G. M. T. + $12^d.907995E$ + $3^d.8386t^2 - 0^d.0362t^3 + 0^d.0246t^4$, where $t = E/1000$.

Two well determined curves by the writer at epochs 1910 and 1917, each based on about 600 comparisons with γ and δ Lyrae, are not considered sufficient to confirm the presence of persistent minor oscillations in the light of β Lyrae.

Six determinations of the range of the light variation of δ Cephei, together with twelve values of this quantity discussed before the Society in a previous paper, support the suggestion that the light range of this star has been measurably variable.

THE PARALLAX OF CAPELLA FROM DESENSITIZED PLATES.

By Zaccheus Daniel.

In the case of a number of the brighter stars it is impossible to reduce the light to equality with the comparison stars by the revolving sector alone. To overcome this difficulty the method of desensitizing a small area at the center of the plate, described by Jordan and Burns at the Middletown meeting in 1921, has been applied as a test to a small list of such stars under observation with the Thaw photographic refractor of the Allegheny Observatory. The first to be finished is Capella.

Twenty plates of three exposures each, equally divided between morning and evening, covering the five epochs from February 1920 to February 1922, yield $+0''.076 \pm 0''.005$ for the parallax and $+0''.085 \pm 0''.006$ for the annual proper motion in right ascension, relative to four comparison stars of about 11.5 photographic magnitude. The probable error for one good plate is $\pm 0''.018$.

An interesting check on this result is furnished by the parallax of the distant companion appearing on the same plates, but not affected by the desensitizing nor by the revolving sector. Thirty-five plates taken between 1915 and 1922 yield $+0''.079 \pm 0''.003$ for the parallax and $+0''.063 \pm 0''.001$ for the annual proper motion in right ascension relative to five comparison stars of about the same photographic magnitude. Three of these were used in deriving the parallax of Capella itself. The probable error for one good plate is $\pm 0''.016$.

A NEW SPECTROCOMPARATOR.

By Ralph E. De Lury.

At the twenty-first meeting of the Society a new form of comparator was suggested, and measurements made with a Hartmann comparator in which the usual silver mask was replaced by a half-silvered surface were reported to have increased accuracy when positive and negative images were overlapped. The double comparator suggested has in the meantime been constructed in the machine-shop of the Dominion Observatory, and the measurements show the expected improvement over spider-line measurements. Lantern slides showed the comparator on its specially constructed table, underneath which is mounted a 50-watt (white glass) bulb which supplies light up through the table to two mirrors which direct the beams through the microscopes, after passing through the two plates to be compared, it being possible to vary the intensity and color of the light for one plate independently of the other. The plate carriers are constructed to take 2.5 in. x 12 in. plates. The screws are one inch in diameter and 15 inches long of half-millimeter pitch. The bronze nuts are split and of 150 threads. They may be adjusted tight to the threads so as to eliminate the errors due to capillary lag found here in oil in the Toepfer machine with loose nut. The comparator may be easily rotated on the table so that reverse measures are made without changing the plates in their carriers or without the need of moving of the observer. It is planned to reflect images of the graduated drums into the focal plane of the plate images and to one side, so that they may be read without taking the eye from the eye-piece, or photographed at one eye-piece while the settings are made at the other.

THE STEWARD OBSERVATORY OF THE UNIVERSITY OF ARIZONA.

By A. E. Douglass.

The 36-inch reflecting telescope of the Steward Observatory is in place, and a number of excellent photographs have been obtained. The instrument is of the finest design throughout, and fitted everywhere with electrical control. The coördination between the mechanical and optical parts was so good that, on fixing the focussing adjustments in the mean position, the eye-piece in the Cassegrain position was found almost exactly in focus. The optical qualities of the mirrors appear to fulfill the highest requirements, but as yet the necessary covering for protection against changes in temperature has not been put on, and therefore the final tests have not yet been made. Electric thermometers have been installed in front of and behind the mirror in different parts of the dome and outside, so that a complete study can be made of temperature conditions.

Astronomers are most cordially invited to visit this new observatory

at any time and especially to try to get an opportunity of seeing it on their southwestern trips in connection with the total eclipse of the sun in September, 1923. It should be remembered that northern Mexico at points near the railroad between Guaymas and Hermosillo will be favorable locations for observing this eclipse. This Mexican region in general has more summer rainfall than the California coast islands, but much less fog.

THE VARIABLE DOUBLE STAR X OPHIUCHI. (B. D. +8°3180)

By C. H. Gingrich.

The relative parallax of this unique object was determined by van Maanen in 1921, as $0''.000 \pm 0''.007$. From measures by Hussey and later by Van Biesbroeck it was shown that the components are nearly in a north and south line. Accordingly van Maanen's parallax plates were measured in declination for the purpose of detecting if possible the displacement due to the variation in relative brightness of the two stars. Fifteen exposures were compared with a given exposure which was made near a maximum of the combined light. A mean displacement of $0''.152$ to the south was found for a group of eight exposures taken about midway between maximum and minimum, although no definite displacement was shown by other exposures made near maximum. The shifting of the image southward after maximum shows the north star to be variable. The measured shift of $0''.152$ in a period less than the interval from maximum to minimum shows the distance between the stars to be somewhat greater than that amount. Both of these conclusions are in agreement with results obtained by Van Biesbroeck from direct observations.

PARALLAXES OF STARS IN THE REGION OF B. D. +31°643.

By C. H. Gingrich.

From a series of plates taken by van Maanen with the 60-inch reflector, the parallaxes and proper motions of twenty stars with reference to six or seven among them which appear not to be related to the nebula, which surrounds this star, were determined. Five of these have a color-index from 0.74 to 0.95 in excess of normal and seem to be involved in the nebula. The mean of the parallaxes of these five stars is $0''.0095 \pm 0''.006$. This is therefore taken to be the parallax of the nebula, equivalent to a distance of 350 light years from the sun.

A FIFTY-FOOT INTERFEROMETER TELESCOPE.

By George E. Hale.

The mechanical and optical problems presented by a 50-foot interferometer are not difficult of solution, but in order to keep the expense within moderate limits, a simple design, involving but little large-scale machine work, is essential. The instrument, the details of which have been worked out by Pease and Nichols, embodies the optical features used by Michelson for the 20-foot interferometer in a mounting of apparently the simplest possible type.

The plane mirrors are carried on a light skeleton girder of structural steel, to be riveted together on Mount Wilson. This girder is 54 feet long and 10 feet deep in the center, tapering toward the ends. Its cross-section at the center is 4½ feet, tapering to a width of 2½ feet at a point 18 feet from the center, and maintaining this width to the extremity of the girder. On the upper surface of the girder, which is approximately straight, the rails which carry the sliding mirrors, carefully planed in sections 12 feet in length (the limit of our planer bed), are supported by leveling screws, which permit them to be accurately aligned. The outer 45° plane mirrors, 15 inches in diameter, are mounted on carriages moved simultaneously toward or away from the center of the girder by long screws driven from a single motor. Their separation may thus range from 7 to 50 feet. To permit stars of any declination to be reached, the 45° mirrors can be rotated simultaneously, by synchronous motors, about the axis joining their centers. The inner 45° plane mirrors, also 15 inches in diameter, fixed in position 26 inches apart on opposite sides of the center of the girder, are provided with fine adjustments, and one of them can be moved slightly for compensation of path. The light received from the outer mirrors is reflected to a paraboloidal mirror, of 36 inches aperture and about 15 feet in focal length, mounted within the girder, at its base. Since the axis of the mirror is normal to that of the girder, the rays are reflected back between the fixed 45° mirrors to a diagonal plane mirror, which sends them to an eye-piece (directly toward the pole) conveniently placed for the observer. The latter sits on a platform attached to the girder on the north.

The girder is carried by a strong polar axis, consisting of a short steel forging mounted on standard roller bearings, supported on a massive pier of concrete. The center of the axis passes through the center of gravity of the girder, which thus remains in balance in all positions. The end thrust is carried partly by the bearings of the polar axis, and partly by two auxiliary rollers moving on curved rails on the north face of the pier, opposite the 36-inch mirror. A worm-gear sector of 10 feet radius, bolted to the girder, is driven by a worm connected with a driving clock at the base of the pier on the north. The range of motion is 1½ hours on each side of the meridian.

Optically the instrument is similar to the 20-foot interferometer, except that a 36-inch mirror replaces the central zone of the 100-inch, while provision is made for motion in declination by the simple expedient of rotating the outer 45° mirrors. Comparison fringes will also be arranged for, and the wedge for compensating differences in path will be like that of the 20-foot interferometer. The new instrument will be covered by a house with double walls of steel, about 60 feet long, 18 feet wide, and 20 feet high. The lower walls, to a height of 8 feet, will be fixed in position but the upper section of the house may be rolled back, leaving the interferometer fully exposed for observations from declination —30° to the Pole.

With this instrument, which is now under construction, it should be possible to check the results obtained with the 20-foot interferometer by simultaneous observations, and to measure the diameters of about thirty stars brighter than the fourth magnitude.

THE ORBITS OF THE SPECTROSCOPIC COMPONENTS OF BOSS 3793 (FOLL.).

By W. E. Harper.

This star was announced as a spectroscopic binary in Volume I, No. 26 of the *Publications of the Dominion Astrophysical Observatory*. The star is of visual magnitude 6.8 and of late F-type and is distant about 3″.5 from a star of 6.1 magnitude and of type F5. The spectra, in fact, are almost identical. The brighter star is constant in velocity, a velocity of approach of 32.3 km/sec. being obtained at this observatory in the general Boss program finished a year ago. Three plates made this year yield an almost identical result of 31.9 km approach. The fainter star whose spectroscopic orbit is now determined has its velocity of the system about 4 km more positive and this suggests the possibility of the pair being a long period visual binary. Burnham states they are relatively fixed having a common proper motion.

Twenty-nine plates of the star under consideration have been secured and on twelve of these the spectrum of the fainter component has been measured. It is considerably fainter than that of the primary but the measures of it are reliable and the results have been incorporated in the least-squares solution. Four of the plates occur at phases where the spectral lines are partially superposed and were discarded and the determination rests upon the equivalent of 37 plates.

Final elements have been obtained through a least-squares solution as follows:

P =	12.822 days	
e =	0.394	± .001
ω_1 =	97°.05	±2°.49
ω_2 =	277°.05	±2°.49
K_1 =	58.31 km	±0.94 km
K_2 =	72.19 km	±1.42 km
γ =	—28.23	±0.57 km
$m_1 \sin^3 i$ =	1.27 ⊙	
$m_2 \sin^3 i$ =	1.03 ⊙	

Final results for the absolute magnitude from the spectroscopic data have not yet been obtained but the star is among the brightest of the F-types, obtained in the general Boss program of radial velocities.

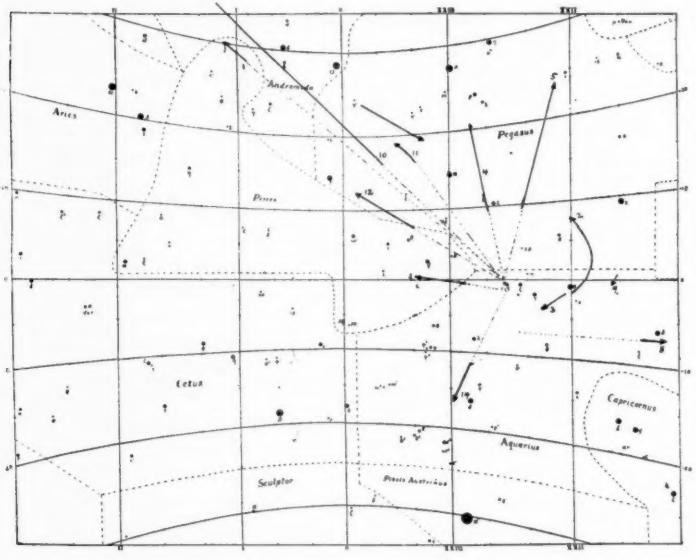
(To be continued.)

OBSERVATIONS OF METEOR SHOWERS IN 1922.

By R. M. DOLE.

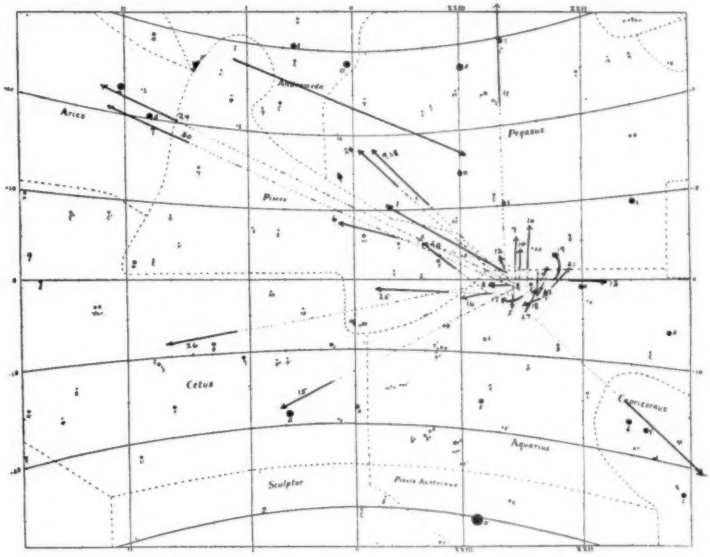
The Aquarids.

The Aquarids seem to return consistently every year in about the same numbers and give every evidence of being a very old radiant area. Observations were made on July 28 and 29, with excellent weather conditions. On July 28 fourteen were observed between 10:15 P. M. and 12:15 A. M.; while on July 29 thirty were observed.

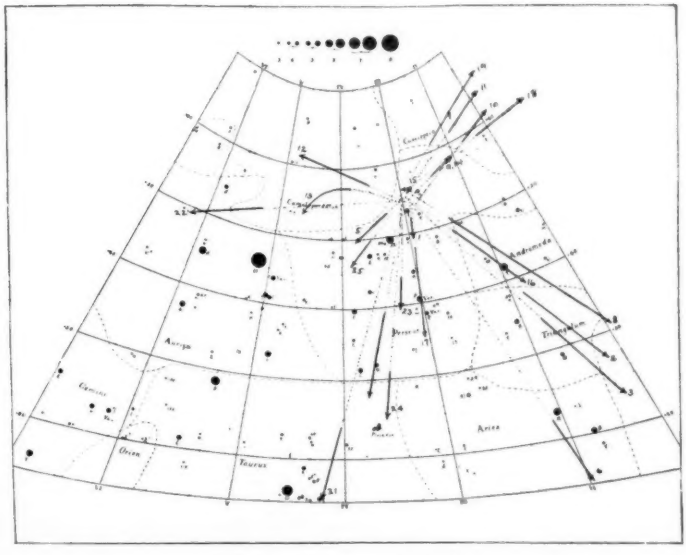


Aquarids, July 28, 1922.

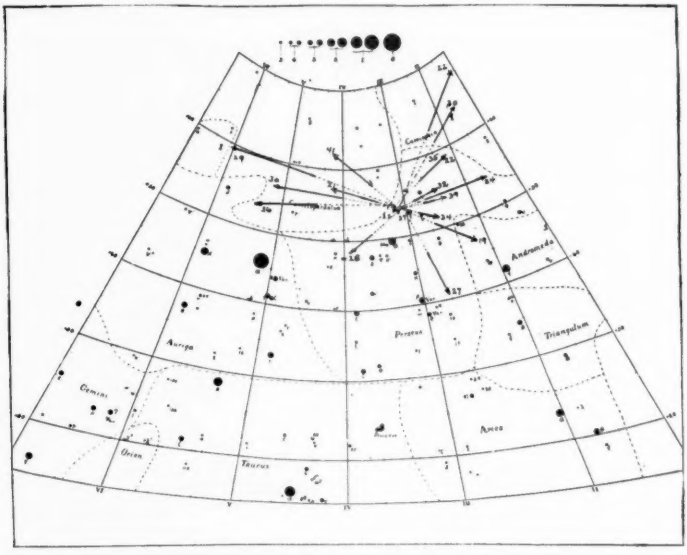
From several years' conclusions it seems that the part of the sky from whence they radiate is a large area rather than a point. The Aquarids are very slow and easy to map, very few leave trails, and several are apt to have a curved path and be very short.



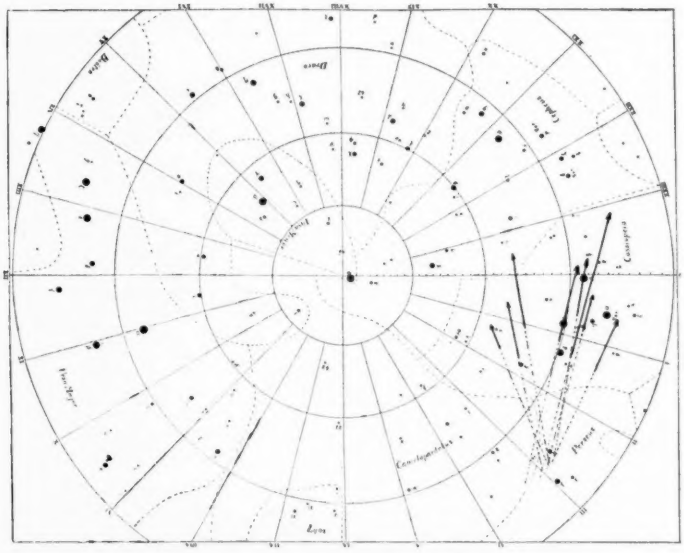
AQUARIDS, JULY 29, 1922.



PERSEIDS, AUGUST 10, 1922.



PERSEIDS, AUGUST 11, 1922.



PERSEIDS, AUGUST 12, 1922.

July 28, 1922.

Time.	Numbers.		Magnitude.	Color.
10:15-10:45 P. M.	3		2-0	3-red
10:45-11:15	3	4 Cygnids, 6 Perseids.	1-1	11-white
11:15-11:45	5		3-2	
11:45-12:15	3		2-3	
			4-4	no trails
			1-5	
			1-6	

July 29, 1922.

10:15-10:45 P. M.	8		1-0	2-red
10:45-11:15	6		4-1	2-blue
11:15-11:45	9	13 Perseids.	3-2	26-white
11:45-12:15	7		7-3	
			5-4	no trails
			1-5	
			9-6	

The Perseids.

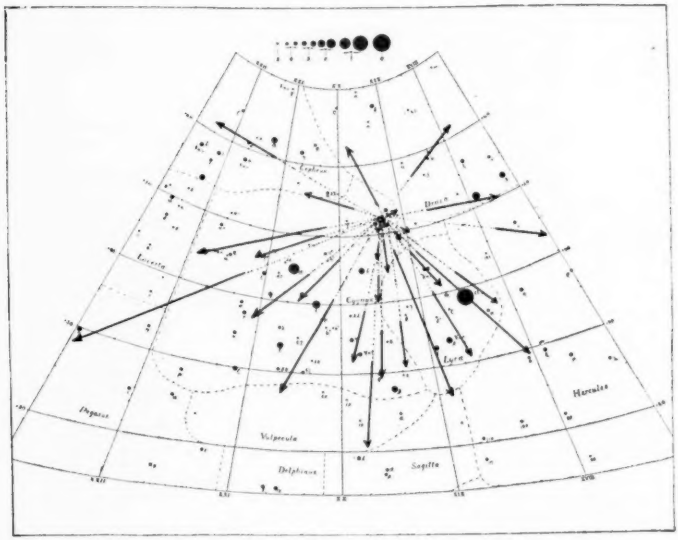
The Perseids for 1922 were considerable of a disappointment, even allowing for a very bright moon, and the promise of last year of good numbers was not fulfilled. In fact the Perseids for the last six or seven years have been few and rather faint, suggesting that the earth is passing through the thin and meager part of the ring. This year there were long periods when not one could be seen and the ones that did appear were rather faint. On August 10 however, number 6 gave the brilliancy of the crescent moon and left a vivid green trail lasting 30 seconds that seemed to drift east-northeast.

The count was as follows:

Date	Time		Number		Magnitude			Color
Aug. 8	15:40-16:10	A. M.	5	Very clear	2-1	1-4		All white
Aug. 9				Cloudy	1-2	1-6		2-trails
Aug. 10	12:00-13:00	A. M.	5	Very clear	1-—3	4-6	1-6	5-trails
	13:00-14:00		9		2-0	6-3		19-white
	14:00-15:00		11		5-1	4-4		5-red
Aug. 11	8:30- 9:30	P. M.	15	Hazy, upper clouds		2-5		1-blue
	9:30- 9:45		3		1-—1	6-4		
			24	trails	10-0	2-5		26-white
	11:30-12:30		16		12-1	1-6		13-red
	12:30-12:45		7	Clouded over	4-2			1-green
Aug. 12	8:00- 8:15		8	Clouded over	5-3			1-blue
					1-0	4-5		6-white
					1-2	1-6		2-red
					1-4			1-trail

The Cygnids.

A fairly active shower of small but faint shooting stars was observed from the constellation Cygnus from August 15 to 26, 1922. The radiant point was very close to Iota Cygni, was very sharply defined, and moved very slowly northeastward only 15 seconds or less a night. It is possible that these meteors continued over a month, for several a night were noticed but not mapped as early as July 28 and 29. There were some very bright individual ones, but for the most part they were



CYGNIDS, AUGUST 15-26, 1922

short and faint. The map gives the paths of those observed August 15 and 16. These Cygnids near the radiant point gave a count of 10 per hour, and seemed to be only observable in the early evening.

East Lansing, Michigan.

The Gulf Stream of the Sky.

On cloudless nights its course I used to trace,
While faring homeward on the dim-lit ways:
A pearly, sea-broad river flung thro' space,
Its isles and shores with beacon lights ablaze.

From garden, too, and casement I would scan
That drift of star dust, galaxy of spheres;
The sun's fleet arrows, swerveless, could not span
The gulf it silvers in ten thousand years.

On moonless nights in town I see no more
The mystic river, awesome to behold—
Only the beacon lights along the shore,
Paled by our radiant roofs and towers of gold.

I have lain oft at night—the stars o'erhead,
The forest still the river lisping by,
The embers of the campfire smoldering red—
And roved that ghostly gulf stream of the sky.

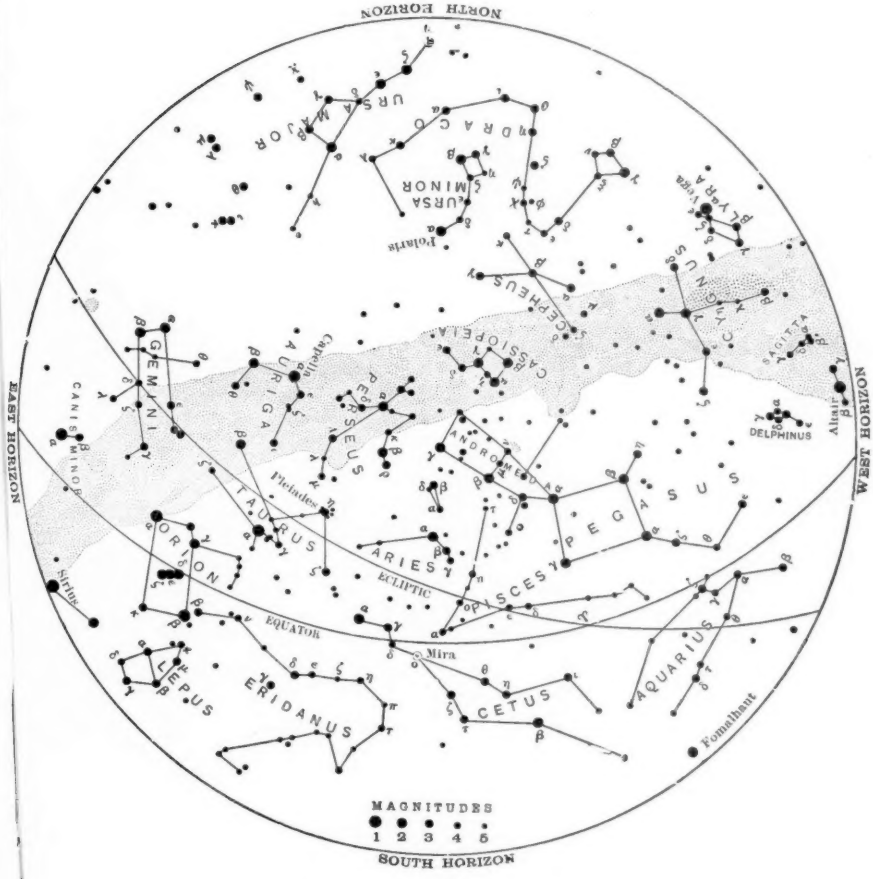
—ANDY (Charles Wesley Anderson.)

(Republished from his *Songs On the Trail*, a booklet containing selections from his contributions to *The Line O' Type*, Chicago Tribune.)

PLANET NOTES FOR DECEMBER.

The phases of the *moon* will occur as follows:

Full Moon	Dec. 4 at 5 A. M.	C. S. T.
Last Quarter	11 " 11 A. M.	"
New Moon	18 " 6 A. M.	"
First Quarter	25 " 12 P. M.	"



THE CONSTELLATIONS AT 9:00 P. M. DECEMBER 1.

The *sun* will move eastward from $16^h\ 27^m$ to $18^h\ 39^m$ during the month. It will move southward until December 22, and after that date will move slowly northward. The time the sun reaches its farthest position south is taken as the calendar date of the beginning of winter in the northern hemisphere. The

path of the sun leads from the constellation Scorpio into the constellation Sagittarius, through a region in which there are no particularly bright stars.

Mercury will be on the opposite side of the sun from the earth on December 6. It will be moving eastward and by the end of the month will be an hour east of the sun. It will however be a short distance south of the sun, and will therefore be very near the horizon at sunset, and consequently not likely to be seen unless special search is made for it.

Venus will be west and north of the sun throughout the month. It will rise more than three hours before the sun at the end of the month and on December 30 will attain its maximum brilliancy. At this time it will be more than one hundred times as bright as a star of magnitude 1.0, and will be very conspicuous as a morning star. It will then be about forty million miles from the earth.

Mars will be in the southwest during the evening throughout the month. It will be about 140,000,000 miles away and hence will not be very bright.

Jupiter will not yet be in favorable position for observations at northern stations. It will rise three or four hours before the sun, but will be fourteen degrees south of the equator.

Saturn will be about an hour and a half west of Jupiter and about ten degrees north. It will be found in the constellation Virgo, a short distance north of the bright star Spica.

Uranus will cross the meridian at five o'clock in the afternoon. It will be between eight and nine degrees south of the equator, in the constellation Aquarius.

Neptune will be in the opposite part of the sky from Uranus. It will be in the constellation Leo, near the bright star Regulus.

Occultations Visible at Washington.

[From the American Ephemeris.]

Date 1922	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
			h m	°	h m	°	h m
Dec. 3	75 Tauri	5.2	8 13	114	9 13	215	0 59
4	115 Tauri	5.3	11 10	67	12 34	280	1 24
5	124 H.[1] Orionis	5.7	6 57	77	7 54	272	0 57
5	292 B. Orionis	6.5	10 47	159	11 11	194	0 23
14	22 B. Librae	6.4	15 48	113	16 46	287	0 58
22	λ Capricorni	5.5	6 0	90	7 9	223	1 9
25	80 B. Piscium	6.3	4 39	36	6 1	267	1 22
26	155 B. Piscium	6.5	5 23	30	6 41	273	1 17
31	318 B. Tauri	5.7	5 26	77	6 33	257	1 7

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1922 December							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8							27	17
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	8	11	16	3	23	19	31	1.
UU Androm		38.5	+30	24	10.7—11.9	1	11.7	5	19	13	6	20	16	28	.
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	2	1	9	13	24	12	31	2.
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	5	3	11	5	23	11	29	13
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	1	1	8	5	22	11	29	15
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	2	21	9	18	23	11	30	8
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	7	5	14	10	21	14	28	18
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	9	11	18	5	27	0		
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	8	17	16	15	24	14		
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6	3	12						
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	2	2	10	17	19	7	27	22
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	5	0	11	19	18	14	25	9
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	7	8	15	6	23	3	31	1
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	9	0	17	7	25	14		
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	8	13	16	10	24	8		
RW Persei		13.3	+42	04	8.8—11.0	13	04.8	8	0			21	5		
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	4	5	13	15	23	1		
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1			11	4	23	14		
TT Aurigæ	5	02.8	+39	27	7.8— 8.7	0	16.0	1	15	14	22	21	14	28	6
RY Aurigæ		11.5	+38	13	10.7—11.7	2	17.5	3	8	11	13	19	17	27	22
RZ Aurigæ		42.9	+31	40	10.6—13.3	3	00.3	4	6	10	7	22	8	28	8
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	9	12	18	4	26	20		
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9	6	17	17	2	27	12		
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	1	17	9	18	17	18	25	18
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	5	16	11	10	22	21	28	14
U Columbæ	6	11.2	—33	03	9.2—10.0	2	19.2	1	5	12	10	18	0	29	5
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	2	18	10	23	19	3	27	8
RW Monoc		29.3	+ 8	54	9.0—10.8	1	21.7	2	6	9	21	17	12	25	3
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	1	12	13	17	23	22		
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	4	20	12	0	19	4	26	8
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	2	12	9	8	22	23	29	18
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	2	0	11	8	20	15	29	22
Y Camelop.		27.6	+76	17	9.5—12	3	07.3	4	11	11	2	24	7	30	21
TX Gemin.		30.3	+17	08	10.0—11.9	2	19.2	4	5	12	15	21	0	29	10
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	4	22	11	8	24	5	30	15
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	2	17	10	0	24	13	31	19
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	3	14	11	17	19	20	27	23
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	4	17	14	5	23	17		
RX Hydræ	9	00.8	— 7	52	9.1—10.5	2	06.8	3	15	10	12	24	4	31	0
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	4	10	10	9	22	6	28	4
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	6	23	13	17	20	11	27	5
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5	2	23	10	9	17	7	25	5
SS Carinæ	10	54.2	—61	23	12.2—12.8	3	07.2	7	1	13	15	20	6	26	20
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	5	14	14	10	23	5		
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	2	16	9	23	24	15	31	23
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	1	17	8	12	15	7	22	2
RZ Centauri	12	55.6	—64	05	8.5— 8.9	1	21.0	1	11	8	23	16	11	24	0
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.1	7	9	17	0	26	14		
SS Centauri		07.2	—63	37	8.8—10.4	2	11.5	1	8	8	19	23	16	31	20
133926 Hydræ	13	39.0	—26	23	8.6—12.7	2	21.5	1	22	7	18	19	8	25	3

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1922 December					
	h	m	°	′		d	h	d	h	d	h	d	h
δ Libræ	14	55.6	— 8	07	4.8— 6.2	2	07.9	3	8	10	5	23	23	30	21
U Coronæ	15	14.1	+32	01	7.6— 8.7	3	10.9	1	1	7	23	14	21	21	18
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.3	5	3	13	13	21	23	30	9
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	1	14	9	6	16	21	24	13
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	6	10	13	18	21	2	28	10
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	7	15	15	21	24	4		
R Aræ		31.1	—56	48	6.8— 7.9	4	10.2	8	14	17	10	26	7		
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1			15	4				
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	3	22	10	17	17	12	24	8
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	6	21	15	7	23	16		
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	6	0	12	5	24	12	30	15
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	6	23	13	3	25	11	31	16
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	3	17	11	2	18	11	25	20
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	6	14	14	18	22	23	31	3
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	6	1	13	14	21	3	28	16
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	4	20	12	14	20	8	28	1
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	2	16	10	16	18	16	26	15
WX Sagittarii		53.6	—17	24	9.2—10.8	2	03.1	8	11	17	0	25	12		
WY Sagittarii	17	54.9	—23	01	9.5—10.6	4	16.0	4	11	13	21	23	5		
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	8	16	19	0	29	8		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	2	2	9	8	23	20	31	2
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	6	7	13	4	20	2	27	0
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2	3	3			18	6		
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	2	9	9	13	23	21	31	1
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	6	10	13	12	20	15	27	18
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	9	6	17	13	25	21		
RR Draconis		40.8	+62	34	9.3—13	2	19.9	7	14	16	2	24	14		
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	7	15	14	7	20	22	27	13
β Lyræ		46.4	+33	15	3.4— 4.1	12	21.8			10	19	23	17		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	3	16	11	8	18	23	26	14
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	1	4	8	18	16	8	23	22
RV Lyræ		12.5	+32	15	11. —12.8	3	14.4	7	2	14	6	21	11	28	16
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	2	2	11	0	18	0	28	22
U Sagittæ		14.4	+19	26	6.5— 9.0	3	09.1	2	7	9	1	22	14	29	8
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	2	19	10	3	17	12	24	21
TT Lyræ		24.3	+41	30	9.4—11.6	5	05.8	4	4	14	16	25	4	30	10
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	5	21	12	10	18	23	25	11
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	1	2	7	2	19	3	25	3
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	5	11	12	2	18	17	25	8
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	9	21	19	0	28	4		
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	7	9	15	19	24	6		
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	6	6	13	1	19	20	26	15
UW Cygni		19.6	+42	55	10.5—13	3	10.8	7	8	14	5	21	3	28	1
V Vulpec.		32.3	+26	15	8.2— 9.8	37	19.0			13	13				
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	9	11	19	1	28	16		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	5	10	14	14	23	19		
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	6	23	14	11	21	23	29	11
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	7	16	15	6	22	21	30	11
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	9	9	19	12	29	14		
VVCygni	21	02.3	+45	23	12.1—13.8	1	11.4	3	23	11	8	18	17	26	3
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	1	2	10	19	20	12	30	4
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	2	8	10	5	18	2	25	23
RT Lacertæ	21	57.4	+43	24	9.1—10.5	5	01.7	2	6	12	9	22	13		
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3					24	5		
RW Lacertæ	22	40.6	+49	08	10.2—11.2	5	04.4	2	5	12	13	17	18	26	3
VW Pegasi		51.7	+32	41	10.0—10.6	5	06.4	5	7	15	20	21	2	31	15
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.4	6	12	14	19	23	2	31	9
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.3	1	8	8	21	23	22	31	11
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	2	1	10	7	18	13	26	19

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922 December							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7			8 11					
SY Cassiop.	0 09 8	+57 52	9.3— 9.9	4 01.7	8 18		16 21		25 1			
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	3 6		11 0		18 17		26 11	
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	7 22				22 17			
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	5 7		13 5		21 4		29 2	
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	6 11		14 6		22 1		29 20	
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	4 18		12 1		19 8		26 15	
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	4				20			
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	7 20		16 10		24 23			
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	6 9		17 12		28 16			
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	7 5		18 20		20 11			
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	8 22		16 14		24 6		31 21	
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3	9 15		19 18		29 21			
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	5 4		22 22		20 15		28 8	
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	5 20		11 9		22 11		27 23	
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	8 4		15 17		23 7		30 19	
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3					20 20			
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	2 21		10 7		17 19		25 6	
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	5 20		13 1		20 6		27 11	
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	1 21		9 19		17 17		25 15	
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4 19		14 23		25 3			
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5					21 5			
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	5 10		13 9		21 8		29 6	
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	6 16		13 8		20 1		26 18	
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	2 22		12 4		21 11		30 18	
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9	7 7		16 1		24 18			
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	5 23		12 18		19 13		26 8	
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	6 11		13 2		19 16		26 7	
S Muscæ	12 07.4	—69 36	6.4— 7.3	9 15.8	3 3		12 19		22 11			
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	1 3		9 2		17 2		25 1	
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	7 11		14 4		20 22		27 15	
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	2 21		8 17		20 8		26 4	
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	4 16		14 2		18 18		28 3	
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5			10 1		27 8			
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	8 14		16 19		25 0			
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	4 21		11 22		18 22		25 23	
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	1 8		9 13		17 18		25 23	
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	3 19		9 7		20 7		31 6	
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	7 17		15 6		22 19		30 8	
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	8 0		14 12		21 22		29 8	
R Triang. Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	4 5		11 0		24 13		31 8	
S Triang. Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	6 5		12 12		25 4		31 12	
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	8 2		17 20		27 14			
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	6 19		15 16		24 12			
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	2 21		8 22		21 2		27 3	
X Sagittarii	17 41.3	—27 48	4 4— 5.0	7 00.3	3 1		10 2		24 2		31 3	
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9	7 17				24 19			
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	3 20		11 10		19 1		26 15	
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	1 10		12 23		24 12		30 7	
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	3 22		10 16		24 4		30 22	
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	5 15		15 23		26 7			
Y Lyræ	34.2	+43 52	11.3—12.3	0 12.1	2 3		8 4		20 5		26 6	
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	6 7		12 10		24 17		30 20	

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922 December							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	2 6	8 5	20 3	26 1				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	4 14	13 16	22 18	31 21				
U Aquilæ	19 24.0	− 7 15	6.2— 6.9	7 00.6	7 8	14 9	21 9	28 10				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	5 14	12 14	19 14	26 14				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	4 6	12 5	20 5	28 4				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	4 20	12 13	20 5	27 22				
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	6 20	14 0	21 5	28 9				
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	2 6	10 15	19 0	27 9				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	2 7	8 14	21 6	27 13				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	8 8		24 17					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1 16	10 13	19 10	28 6				
UY Cygni	52.3	+30 03	9.6—10.4	0 13.5	6 23	13 16	20 10	27 3				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	7 16	14 9	21 2	27 19				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		15 13		30 7				
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	8 3	15 23	23 20	31 17				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	4 1	10 23	24 17	31 15				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 16	15 9	20 6	29 23				
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	5 12	14 3	22 19	31 11				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	6 6	11 15	22 8	27 17				
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	4 5	15 2	25 23					
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	7 3	13 13	19 23	26 9				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	5 7	15 6	20 5	30 5				
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	3 21	14 18	20 5	31 2				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	1 15	12 12	17 23	28 20				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 4	7 11	20 2	26 9				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4		12 21	25 0					
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	6 11	13 10	20 10	27 9				

Monthly Report of the American Association of Variable Star Observers, August 20 to September 20, 1922.

With the present splendid report the Association brings to a close one of its most successful years, both from the point of view of actual accomplishment, as evidenced by the detailed summaries of observations in the adjoining table, and from that of growth in membership and resources looking toward still greater achievement in the future. The following have been recently elected to membership in the Association:

P. F. Jennings, McCracken, Kansas,
Prof. J. A. Brown, Beirut, Syria,
L. E. Cunningham, Wiscasset, Maine,
Roy Marshall, Lebanon, Ohio,
W. E. Inglis, Bridgeport, Connecticut,
K. Nakamura, Kyoto, Japan.

Maximum 188 of SS Cygni, 213843, was well observed by many, with one or two discrepancies. Observers are again cautioned to check the printed report from their note-books and report any errors.

Mr. D. H. Menzel, who spent the summer at Harvard College Observatory, has returned to Princeton to continue his graduate work there. Miss A. J. Cannon, our Honorary Member, has returned to Harvard College Observatory

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922.
August 0 = J. D. 2423267 September 0 = J. D. 2423298

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
001032 S SCULPTORIS—								
	3314.8	10.0 Pt.						
001046 X ANDROMEDAE—								
	3281.7	10.9 Wf,	3287.7	12.7 M,	3288.8	11.8 Wf,	3308.8	11.6 Wf
001620 T CETI—								
	3270.6	5.5 An,	3287.6	5.4 An,	3287.6	5.8 L.		
001726 T ANDROMEDAE—								
	3288.6	9.2 O,	3302.6	9.1 O,	3307.9	8.6 Br,	3310.6	8.9 Pt.
001755 T CASSIOPEIAE—								
	3271.6	7.8 L,	3279.4	7.8 L,	3285.5	8.0 Gi,	3294.8	7.9 L,
	3302.6	8.6 O,	3310.6	8.9 Pt.				
001838 R ANDROMEDAE—								
	3284.8	14.4 Wf,	3290.9	14.4 Wf,	3308.8	<13.8 Wf,	3310.6	14.0 Pt.
001909 S CETI—								
	3287.6	12.5 L,	3293.9	<11.7 Sg,	3312.9	10.6 Sg.		
003179 Y CEPHEI—								
	3309.7	<12.4 Br.						
004047 U CASSIOPEIAE—								
	3281.7	8.7 Wf,	3287.7	9.2 M,	3288.8	8.5 Wf,	3308.8	9.4 Wf,
	3310.6	9.5 Pt,	3311.7	9.8 Lc,	3314.6	9.9 Gd.		
004132a RW ANDROMEDAE—								
	3281.7	8.8 Wf,	3288.6	9.1 O,	3288.8	8.9 Wf,	3303.6	9.4 O,
	3308.8	8.4 Wf,	3310.6	9.8 Pt.				
004533 RR ANDROMEDAE—								
	3281.7	<14.0 Wf,	3288.9	<13.0 Wf.				
004746a RV CASSIOPEIAE—								
	3269.6	<13.7 L,	3271.6	<13.7 L,	3281.7	13.7 Wf,	3288.9	<14.0 Wf,
	3294.4	<14.0 L,	3310.6	14.8 Pt.				
004958 W CASSIOPEIAE—								
	3278.5	11.6 Gi,	3280.7	<11.2 Br,	3287.6	<11.2 Cg,	3291.5	11.4 Gi,
	3300.6	<11.2 Cg,	3307.9	<11.5 Br,	3310.6	12.0 Pt,	3311.7	<11.5 Lc,
	3314.6	12.0 Gd.						
010940 U ANDROMEDAE—								
	3281.7	11.7 Wf,	3288.9	11.9 Wf,	3311.7	<11.8 Lc.		
011041 UZ ANDROMEDAE—								
	3283.8	14.7 Wf,	3290.8	15.0 Wf.				
011272 S CASSIOPEIAE—								
	3283.8	13.2 Wf,	3287.7	13.5 M,	3290.8	13.4 Wf,	3308.7	13.5 Wf,
	3310.6	14.0 Pt.						
011712 U PISCIUM—								
	3310.6	11.0 Pt.						
012502 R PISCIUM—								
	3310.6	11.5 Pt.						
013238 RU ANDROMEDAE—								
	3283.8	13.0 Wf,	3290.8	12.7 Wf,	3310.7	11.8 Pt.		
013338 Y ANDROMEDAE—								
	3310.7	14.0 Pt.						
014958 X CASSIOPEIAE—								
	3312.6	12.0 Pt.						
015354 U PERSEI—								
	3293.6	9.9 Cg,	3311.6	9.5 Cg,	3312.6	10.0 Pt.		
015912 S ARIETIS—								
	3312.6	13.2 Pt.						
021024 R ARIETIS								
	3268.6	12.3 Gi,	3286.6	12.9 Gi,	3287.6	12.4 L,	3296.5	12.0 Gi,
	3307.9	10.8 Br,	3312.6	10.6 Pt.				
021143a W ANDROMEDAE—								
	3278.5	10.5 Gi,	3283.8	10.2 Wf,	3290.8	9.6 Wf,	3291.5	9.6 Gi,
	3302.6	8.6 O,	3312.6	7.5 Pt.				

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
021281 Z CEPHEI—												
	3283.8	<14.0	Wf.	3284.8	14.3	Wf.	3287.8	14.4	Wf.	3290.8	<14.0	Wf.
021403 o CETI—												
	3270.6	6.7	An.	3271.6	6.7	L.	3287.6	7.2	L.	3292.6	7.8	An.
	3293.9	7.6	Sg.	3296.6	7.8	An.	3298.9	7.6	Ca.	3312.7	7.4	Pt.
	3212.9	8.0	Sg.									
021558 S PERSEI—												
	3312.6	11.0	Pt.									
022150 RR PERSEI—												
	3283.9	14.0	Wf.	3290.8	14.2	Wf.						
022813 U CETI—												
	3312.7	10.5	Pt.									
022980 RR CEPHEI—												
	3271.6	11.3	L.	3280.7	11.0	Br.	3283.9	11.8	Wf.	3285.4	11.4	L.
	3290.8	11.8	Wf.	3296.6	12.3	L.	3308.8	<11.9	Br.			
023133 R TRIANGULI—												
	3288.6	9.3	O.	3312.6	7.3	Pt.						
024356 W PERSEI—												
	3291.7	10.3	Ca.	3307.9	9.6	Br.	3310.6	9.3	Gi.	3312.6	10.2	Pt.
030514 U ARIETIS—												
	3268.6	12.1	Gi.	3295.6	12.9	Gi.						
031401 X CETI—												
	3283.9	9.0	Wf.	3287.6	8.7	L.	3290.9	9.0	Wf.	3312.7	10.3	Pt.
032043 Y PERSEI—												
	3312.6	9.0	Pt.									
032335 R PERSEI—												
	3278.6	9.4	Gi.	3291.5	8.7	Gi.	3312.7	8.1	Pt.			
042209 R TAURI—												
	3312.7	9.2	Pt.									
042215 W TAURI—												
	3293.9	9.2	Sg.	3307.9	7.0	Br.	3312.7	9.5	Pt.	3312.9	9.0	Sg.
043065 T CAMELOPARDALIS—												
	3271.6	8.8	L.	3279.4	9.2	L.	3294.4	9.6	L.	3312.7	10.0	Pt.
043208 RX TAURI—												
	3314.8	12.5	Pt.									
043274 X CAMELOPARDALIS—												
	3308.0	11.9	Br.	3312.7	12.0	Pt.						
044617 V TAURI—												
	3288.9	<12.4	Wf.	3295.0	13.0	Wf.						
045307 R ORIONIS—												
	3286.6	9.4	Gi.									
045514 R LEPORIS—												
	3292.6	7.5	L.	3298.9	7.0	Pt.	3299.6	7.4	L.	3309.1	8.3	Ct.
050003 V ORIONIS—												
	3298.9	11.8	Pt.									
050022 T LEPORIS—												
	3298.9	12.2	Pt.									
050953 R AURIGAE—												
	3307.7	8.8	Br.	3312.7	9.1	Pt.						
052034 S AURIGAE—												
	3271.6	9.6	L.	3312.7	8.6	Pt.						
052036 W AURIGAE—												
	3269.6	<12.5	L.	3286.6	13.6	Gi.						
052404 S ORIONIS—												
	3314.8	7.7	Pt.									
053005a T ORIONIS—												
	3296.6	10.2	L.	3298.9	10.2	Pt.	3299.6	9.9	L.	3313.8	9.6	Pt.
053068 S CAMELOPARDALIS—												
	3312.7	8.5	Pt.									
053531 U AURIGAE—												
	3307.9	11.1	Br.	3314.8	11.7	Pt.						

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
054319 SU TAURI—												
	3271.6	9.7	L.	3283.9	9.4	Wf.	3295.0	9.4	Wf.	3296.6	9.3	L.
	3298.9	9.5	Pt.	3308.0	9.4	Br.	3313.8	9.5	Pt.	3314.8	9.6	Pt.
054920a U ORIONIS—												
	3298.9	6.4	Ca.	3313.8	6.5	Pt.						
054974 V CAMELOPARDALIS—												
	3283.8<13.5		Wf.	3285.4<14.0		Gi.	3290.8<13.5		Wf.	3308.7<14.5		Wf.
055353 Z AURIGAE—												
	3283.9	10.1	Wf.	3290.8	10.6	Wf.	3294.7	10.6	Wf.	3312.7	10.9	Pt.
060450 X AURIGAE—												
	3307.9	8.8	Br.	3312.7	9.4	Pt.						
060547 SS AURIGAE—												
	3268.6<13.8		Gi.	3269.6<12.4		L.	3271.6<12.4		L.	3276.6<12.6		Gi.
	3278.6<12.4		Gi.	3279.6<13.8		Gi.	3280.6<13.8		Gi.	3283.9<13.7		Wf.
	3284.6<13.8		Gi.	3286.6<13.8		Gi.	3287.6	11.8	Gi.	3287.6	11.6	L.
	3288.6	11.2	Gi.	3288.9	11.2	Wf.	3290.8	11.6	Wf.	3291.5	12.0	Gi.
	3291.8	12.1	Wf.	3292.6	12.4	L.	3292.7<12.6		Pt.	3294.6<12.7		Gi.
	3294.7<12.4		Pt.	3295.0	14.6	Wf.	3295.6<13.8		Gi.	3296.5<13.9		Gi.
	3296.5<13.9		L.	3298.9<12.6		Pt.	3299.6<13.9		L.	3305.8<12.6		Pt.
	3308.0<11.6		Br.	3310.7<12.4		Pt.	3312.7<12.4		Pt.	3313.8<12.4		Pt.
	3314.8<12.6		Pt.	3315.7<12.6		Pt.	3316.7<12.4		Pt.			
063558 S LYNCIS—												
	3308.0	9.7	Br.	3312.7	10.5	Pt.						
064030 X GEMINORUM—												
	3280.6	12.5	Gi.									
064932 NOVA GEMINORUM #2—												
	3296.6	13.8	L.									
065355 R LYNCIS—												
	3276.6	8.8	Gi.	3283.9	9.2	Wf.	3290.8	9.4	Wf.	3296.5	9.5	Gi.
070122a R GEMINORUM—												
	3298.9	10.5	Pt.									
070122b Z GEMINORUM—												
	3298.9	12.4	Pt.									
070122c TW GEMINORUM—												
	3298.9	8.4	Pt.									
070310 R CANIS MINORIS—												
	3299.6	11.3	L.									
071713 V GEMINORUM—												
	3298.9	13.0	Pt.									
072708 S CANIS MINORIS—												
	3298.9	10.2	Pt.	3299.6	10.1	L.						
073508 U CANIS MINORIS—												
	3299.6	9.5	L.									
074922 U GEMINORUM—												
	3292.6<10.9		L.	3295.0<13.2		Wf.	3295.6<12.7		Gi.	3296.6<13.7		L.
	3299.6<13.7		L.									
083350 X URSAE MAJORIS—												
	3314.8	10.6	Pt.									
093934 R LEONIS MINORIS—												
	3299.6	12.0	L.									
103769 R URSAE MAJORIS—												
	3257.3	7.9	Jp.	3268.4	7.8	Jp.	3288.6	8.1	Cd.	3288.6	8.1	O.
	3292.6	7.8	Pt.	3293.6	8.4	Ca.	3304.7	8.4	Sg.	3307.6	8.8	O.
	3309.7	8.5	Br.	3310.7	8.7	Ct.	3311.7	8.6	Ct.	3314.7	8.8	Ct.
122532 T CANUM VENATICORUM—												
	3286.6	9.3	Pt.									
123160 T URSAE MAJORIS—												
	3257.4	11.0	Jp.	3268.4	9.5	Jp.	3283.5	8.6	Ro.	3285.5	8.4	Ro.
	3287.6	8.2	Pi.	3287.6	8.0	Gd.	3288.6	8.1	O.	3288.6	7.8	Cd.
	3290.5	8.1	Ro.	3292.6	7.5	Pt.	3294.5	7.9	Ro.	3296.5	7.9	Ro.
	3299.6	7.8	Ca.	3304.7	7.8	Sg.	3307.6	8.1	O.	3310.7	8.1	Ct.
	3311.7	8.0	Ct.	3314.7	8.2	Ct.						

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
123307 R VIRGINIS—												
	3262.3	10.0	Jp.									
123459 RS URSAE MAJORIS—												
	3280.7	12.3	Wf,	3287.6	12.9	Gd,	3287.7	12.8	Pi,	3288.7	12.6	Wf,
	3292.6	13.0	Pt,	3305.7	13.4	Wf.						
123961 S URSAE MAJORIS—												
	3257.4	11.1	Jp,	3268.4	10.0	Jp,	3285.5	9.7	Ro,	3287.6	9.0	Pi,
	3287.6	9.2	Cg,	3287.6	9.0	Gd,	3288.6	9.2	O,	3290.4	9.5	An,
	3290.5	9.1	Ro,	3292.6	8.9	Pt,	3293.3	8.8	L,	3294.5	9.8	Ro,
	3296.5	8.6	Ro,	3299.6	9.5	Ca,	3304.7	8.8	Sg,	3307.6	9.0	O,
	3310.7	8.4	Ct,	3311.7	8.7	Ct,	3314.7	8.7	Ct.			
124606 U VIRGINIS—												
	3262.3	8.7	Jp.									
133273 T URSAE MINORIS—												
	3281.7	9.3	Wf,	3288.7	9.3	Wf,	3294.7	9.2	Br,	3305.7	10.2	Wf,
	3309.7	10.5	Br.									
134440 R CANUM VENATICORUM—												
	3257.4	10.4	Jp,	3262.3	10.3	Jp,	3268.4	10.4	Jp,	3292.6	11.6	Pt.
	3293.6	<10.4	Cg.									
140113 Z BOOTIS—												
	3280.7	<14.0	Wf,	3288.7	14.4	Wf,	3305.7	<12.5	Wf.			
141567 U URSAE MINORIS—												
	3263.4	10.5	Au,	3285.6	11.0	Pw,	3286.7	11.3	Pt,	3287.6	11.0	Cg.
	3314.6	11.0	Cg.									
141954 S BOOTIS—												
	3276.4	8.5	Gi,	3283.3	8.5	L,	3286.7	8.7	Pt,	3289.6	8.8	Ya,
	3289.6	8.9	Gd,	3293.4	8.7	Gi,	3307.7	9.7	Sg,	3311.5	9.6	Gd.
142539 V BOOTIS—												
	3285.4	10.3	L,	3285.8	10.8	Sg,	3286.7	10.5	Pt,	3289.6	10.8	Ya,
	3289.6	11.2	Gd,	3291.6	10.7	Ca,	3295.5	9.8	Ro,	3304.7	10.6	Sg,
	3311.5	11.1	Gd.									
142584 R CAMELOPARDALIS—												
	3257.4	8.8	Jp,	3268.4	9.2	Jp,	3278.3	10.4	Jp,	3285.4	10.6	Gi,
	3286.7	10.3	Pt,	3288.3	10.8	Jp,	3298.4	11.0	Gi,	3309.7	11.9	Br.
143227 R BOOTIS—												
	3285.8	7.5	Sg,	3286.7	6.4	Pt,	3289.5	7.8	Gd,	3289.6	7.5	Ya,
	3293.6	7.7	Ca.	3302.7	7.5	Sg,	3303.6	7.9	O,	3311.5	7.9	Gd.
144918 U BOOTIS—												
	3268.4	11.0	Gi,	3279.4	10.2	Gi,	3289.4	9.8	Gi,	3289.6	9.9	Gd,
	3311.5	10.4	Gd.									
150018 RT LIBRAE—												
	3260.3	<13.	Bp.									
150519 T LIBRAE—												
	3286.6	11.8	Pt.									
150605 Y LIBRAE—												
	3283.3	<12.6	L.									
151520 S LIBRAE—												
	3279.3	11.2	L.									
151714 S SERPENTIS—												
	3268.4	8.6	L,	3280.7	8.5	Wf,	3288.7	8.4	Wf,	3293.4	8.1	L,
	3293.6	8.2	Ca,	3305.7	8.6	Wf,	3313.5	9.1	Ya.			
151731 S CORONAE BOREALIS—												
	3281.7	12.9	Wf,	3285.6	12.9	Pc,	3287.7	11.3	Sg,	3288.7	12.9	Wf,
	3291.6	<11.1	Ca,	3292.6	12.4	Pt,	3304.7	<10.3	Sg,	3305.7	12.4	Wf.
152714 RU LIBRAE—												
	3283.3	10.8	L,	3286.6	10.9	Pt.						
153215 W LIBRAE—												
	3290.6	12.3	B.									
153378 S URSAE MINORIS—												
	3281.5	8.6	Ro,	3281.7	8.2	Wf,	3283.5	8.5	Ro,	3286.7	8.4	Pt,
	3287.5	8.5	Ro,	3287.7	8.6	Sg,	3288.7	8.4	Wf,	3291.5	8.6	Ro,

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
153378 S URSAE MINORIS—Continued.												
	3291.6	8.6	Ca,	3294.5	8.9	Ro,	3295.5	8.9	Ro,	3297.8	8.6	Sg.
	3300.5	9.1	Ca,	3305.5	9.4	Ro,	3305.7	8.6	Wf,	3308.0	8.7	Br,
	3312.5	9.6	Ro,	3313.5	9.6	Ya.						
154428 R CORONAE BOREALIS—												
	3267.0	7.0	Kd,	3268.4	6.8	L,	3275.4	6.9	L,	3276.4	6.7	Gi,
	3279.4	6.3	L,	3279.8	6.6	Jb,	3280.4	6.4	An,	3281.0	6.6	Kd,
	3281.7	6.6	Wf,	3282.7	6.5	Jb,	3282.7	6.2	To.	3282.7	6.3	Br.
	3283.1	6.6	Kd,	3283.7	6.4	Wf,	3284.4	6.3	An,	3284.4	6.5	Gi.
	3284.7	6.3	Br,	3284.7	6.3	Wf,	3285.6	6.3	Pc,	3285.6	6.1	Pw.
	3285.7	6.5	Wf,	3285.8	6.3	Sg.	3286.6	6.3	Pt,	3286.7	6.4	Sg.
	3287.0	6.4	Kd,	3287.4	6.3	An,	3287.6	6.2	Pi,	3287.6	6.5	Cg.
	3287.6	6.7	Gd,	3287.7	6.6	Sg,	3287.7	6.3	Pt,	3288.6	6.7	Su,
	3288.6	6.2	Pt,	3288.7	6.2	Wf,	3288.7	6.6	Sg.	3289.6	6.4	Ya,
	3289.6	6.5	Gd,	3289.6	6.4	Pi,	3289.7	6.4	Sg,	3289.7	**6.8**	**Ct,**
	3290.4	6.3	An,	3290.6	6.5	Pi,	3290.7	6.5	Ct,	3290.7	6.3	Wf,
	3290.8	6.3	Br,	3291.6	6.4	Ca,	3291.7	6.3	Wf,	3291.7	6.4	Ct,
	3291.8	6.5	Jb,	3292.6	6.2	Pt,	3292.7	6.4	Wf,	3293.6	6.5	Gd.
	3293.6	6.3	Ca,	3293.7	6.4	Wf,	3293.7	6.2	Ct,	3294.4	6.3	Gi,
	3294.7	6.3	Wf,	3294.7	6.4	Pt,	3295.5	6.3	Ro,	3295.6	6.3	Ca.
	3295.7	6.4	Jb,	3295.7	6.5	Ct,	3297.6	6.5	Gd,	3297.6	6.2	Pt.
	3298.6	6.2	Pt,	3299.5	6.2	Ca,	3299.7	6.4	Ct,	3302.5	6.2	Ca,
	3302.6	6.3	O,	3302.7	6.2	Sg,	3302.7	6.2	Br,	3303.6	6.2	Pt,
	3303.7	6.4	Ct,	3304.6	6.1	Pt.	3304.7	6.2	Sg,	3305.6	6.2	Pt.
	3305.7	6.3	Wf,	3305.7	6.2	Br,	3306.6	6.1	Pt,	3307.7	6.3	Ct,
	3308.5	6.1	Ca.	3308.6	6.5	Ct,	3308.6	6.5	Gd,	3308.7	6.0	Sg.
	3308.7	6.4	Wf,	3309.6	6.0	Pt,	3309.7	**6.1**	**Ct,**	3310.6	6.1	Pt,
	3310.7	6.3	Br,	3310.7	6.3	Ct.	3311.6	6.4	Cg,	3311.6	6.3	Ct,
	3311.6	6.1	Pt.	3312.6	6.1	Pt,	3313.6	6.1	Pt,	3313.7	**6.5**	**Ct,**
	3314.6	6.4	Cg.	3314.7	6.1	Ct,	3315.6	6.1	Pt,	3316.6	**6.2**	**Pt,**
	3318.6	6.0	Ca.									
154536 X CORONAE BOREALIS—												
	3281.7	12.8	Wf,	3286.7	13.4	Pt,	3288.7	13.1	Wf,	3308.7	13.3	Wf.
154615 R SERPENTIS—												
	3285.8	<12.1	Sg,	3286.7	12.0	Pt,	3289.6	<12.1	Ya,	3290.6	12.8	B,
	3293.6	<11.7	Ca,	3307.7	<10.9	Sg.						
154639 V CORONAE BOREALIS—												
	3260.4	8.7	Bp,	3267.4	8.9	Bp,	3267.4	7.9	Au,	3268.4	9.0	Au,
	3268.4	9.1	Bp,	3275.4	8.9	Bp,	3281.7	8.1	Wf,	3282.4	9.0	Bp.
	3286.7	7.0	Pt,	3288.4	8.9	Bp,	3288.7	8.0	Wf,	3294.4	8.5	Bp.
	3302.6	8.2	O,	3305.7	7.5	Wf.						
154715 R LIBRAE—												
	3292.6	10.5	Pt.									
155018 RR LIBRAE—												
	3292.6	10.5	Pt.									
155823 RZ SCORPII—												
	3292.6	9.7	Pt.									
160118 R HERCULIS—												
	3290.6	<9.9	Pi,	3292.6	14.5	Pt.						
160210 U SERPENTIS—												
	3285.7	9.1	Pw,	3285.8	9.4	Sg,	3286.7	8.6	Pt,	3288.6	9.1	Pw.
	3302.6	9.2	O,	3307.7	9.2	Sg,	3311.6	9.6	Cd,	3313.5	9.6	Ya.
160625a RU HERCULIS—												
	3281.7	13.6	Wf,	3285.6	13.3	Pc,	3286.7	13.8	Pt.	3288.7	13.3	Wf,
	3305.7	13.3	Wf.									
160625b SX HERCULIS—												
	3281.7	8.8	Wf,	3283.7	8.7	Wf,	3284.7	8.7	Wf,	3285.7	8.6	Wf.
	3286.6	8.5	Pt,	3287.7	8.5	Wf.	3288.6	8.5	Pt,	3288.7	8.6	Wf.
	3290.7	8.4	Wf,	3291.7	8.5	Wf.	3292.6	8.2	Pt.	3293.7	8.3	Wf.
	3298.6	7.7	Pt,	3303.6	8.0	Pt,	3305.6	8.0	Pt,	3305.7	7.8	Wf,
	3307.8	7.8	Wf,	3309.6	7.8	Pt.	3312.6	8.0	Pt,	3316.6	8.1	Pt.

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
161122a R SCORPII—												
	3257.4	12.4	Jp,	3287.6	<13.7	M.						
161122b S SCORPII—												
	3257.4	<12.6	Jp.	3287.6	13.5	M.	3289.3	<12.6	Jp.	3292.6	13.5	Pt.
161122c T SCORPII—												
	3287.6	11.0	M,	3288.6	10.5	Pw,	3292.6	10.9	Pt.			
161138 W CORONAE BOREALIS—												
	3281.7	11.8	Wf,	3288.8	12.0	Wf,	3292.6	12.1	Pt.	3308.7	12.9	Wf.
161607 W OPHIUCHI—												
	3292.6	14.0	Pt.									
162112 V OPHIUCHI—												
	3267.4	9.2	Au,	3267.4	9.3	Bp,	3277.4	8.2	Bp,	3281.4	8.2	Bp,
	3287.4	8.2	Bp.	3292.6	7.4	Pt.	3294.3	8.2	Bp.			
162119 U HERCULIS—												
	3284.4	11.8	Gi,	3284.7	12.0	Wf,	3285.6	12.2	Pc,	3289.7	10.4	Ct,
	3290.7	12.0	Wf,	3292.6	12.0	Pt,	3308.5	<11.0	Ca,	3308.7	13.1	Wf.
162319 Y SCORPII—												
	3278.4	12.3	Gi,	3287.6	11.5	B,	3290.6	11.4	B,	3293.3	11.6	Gi,
	3310.6	11.3	B.									
162807 SS HERCULIS—												
	3257.4	12.0	Jp,	3262.3	12.1	Jp,	3283.4	10.1	Bp,	3285.3	9.9	Bp,
	3287.6	10.7	B,	3289.7	10.7	Ct,	3290.7	<10.5	Ct,	3291.7	10.6	Ct.
	3292.6	10.5	Pt,	3295.3	9.6	Bp,	3307.7	10.0	Ct,	3308.7	9.9	Ct,
	3309.7	9.8	Ct,	3310.6	9.9	Gd,	3310.7	9.8	Ct,	3311.7	9.7	Ct.
	3313.6	8.9	Hu,	3316.5	9.2	Ya.						
163137 W HERCULIS—												
	3287.6	12.5	B,	3292.7	12.5	Pt.						
163172 R URSAE MINORIS—												
	3289.4	9.4	Bp,	3291.4	9.8	Bp,	3296.5	9.5	Bp.			
163266 R DRACONIS—												
	3290.6	12.7	B,	3292.7	13.0	Pt.	3309.7	12.0	Br.	3315.7	<10.0	Ca.
164055 S DRACONIS—												
	3287.6	7.7	M.									
164715 S HERCULIS—												
	3276.4	11.0	Gi,	3285.7	10.6	Pw,	3287.4	10.2	Gi,	3291.6	10.4	Ca,
	3292.7	10.3	Pt,	3310.6	9.5	Gd,	3316.6	9.0	Ya,	3318.6	8.7	Ca.
165202 SS OPHIUCHI—												
	3292.7	9.2	Pt,	3303.6	10.5	Gd.						
165631 RV HERCULIS—												
	3287.6	15.0	M,	3312.6	15.0	Pt.						
170215 R OPHIUCHI—												
	3289.7	<10.2	Ct,	3290.7	<10.2	Ct,	3307.7	<10.6	Ct.			
170627 RT HERCULIS—												
	3284.7	13.2	Wf,	3290.7	13.0	Wf,	3307.8	11.4	Wf.			
171401 Z OPHIUCHI—												
	3262.4	12.3	Jp,	3277.7	12.3	To,	3278.3	12.4	Jp,	3284.4	12.3	Gi,
	3288.3	12.5	Jp,	3290.6	12.4	B,	3292.7	12.5	Pt,	3293.7	12.3	To,
	3294.4	12.3	Gi,	3295.6	<11.2	Ca.						
171723 RS HERCULIS—												
	3264.3	12.1	Jp,	3284.7	12.6	Wf,	3285.7	<10.7	Pw,	3288.4	12.3	Jp,
	3288.4	12.4	Dp,	3288.6	<11.0	Pw,	3290.7	12.5	Wf,	3292.7	12.4	Pt,
	3308.7	12.7	Wf.									
172809 RU OPHIUCHI—												
	3262.4	9.7	Jp,	3275.7	10.6	To,	3277.7	11.0	To,	3281.7	11.4	To,
	3285.7	11.4	Pw,	3286.7	11.8	To,	3288.6	11.5	Pw,	3292.7	12.0	Pt,
	3293.7	12.1	To.									
174406 RS OPHIUCHI—												
	3292.7	11.1	Pt.									
175111 RT OPHIUCHI—												
	3264.3	<12.4	Jp,	3281.7	<12.4	To,	3288.3	<12.7	Jp,	3293.7	<12.4	To.

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
175458a T DRACONIS—												
	3269.4	10.0	Au.	3269.4	10.3	Bp.	3277.4	10.2	Bp.	3284.4	9.7	Gi.
	3287.6	10.0	M.	3295.4	10.2	Bp.	3314.6	11.0	Gd.			
175458b UY DRACONIS—												
	3287.6	11.0	M.	3314.6	11.7	Gd.						
175519 RY HERCULIS—												
	3277.7	10.4	To.	3281.7	10.1	To.	3286.7	9.8	To.	3289.3	9.3	Jp.
	3292.7	9.3	Pt.	3293.7	9.3	To.	3297.6	9.3	Gd.	3310.6	9.4	Gd.
175654 V DRACONIS—												
	3264.3	11.6	Jp.	3286.5	7.6	Bp.	3292.5	7.6	Bp.			
180531 T HERCULIS—												
	3262.4	12.2	Jp.	3278.3	13.0	Jp.	3285.7	<11.0	Pw.	3286.8	12.4	To.
	3288.3	13.1	Jp.	3289.5	11.5	Bp.	3289.7	<10.4	Ct.	3290.7	10.6	Ct.
	3290.7	<12.4	Br.	3291.6	<11.0	Ca.	3292.7	12.5	Pt.	3293.8	12.4	To.
	3307.7	10.2	Ct.	3307.7	10.5	Sg.	3308.7	9.8	Ct.	3310.6	10.2	Gd.
	3313.6	10.0	Hu.	3314.7	9.5	Ct.	3318.6	9.1	Ca.			
180565 W DRACONIS—												
	3264.3	11.1	Jp.	3289.4	11.8	Jp.	3290.7	12.0	Br.	3292.7	12.0	Br.
180666 X DRACONIS—												
	3264.3	<11.8	Jp.	3289.4	<11.8	Jp.	3290.7	<12.0	Br.			
180911 NOVA OPHIUCHI #4—												
	3284.4	12.1	Gi.	3292.7	12.9	Pt.						
181103 RY OPHIUCHI—												
	3268.5	9.6	Gi.	3279.4	10.6	Gi.	3283.7	11.6	Wf.	3287.7	11.7	Wf.
	3289.4	11.3	Gi.	3290.7	12.0	Wf.	3292.7	11.9	Pt.	3294.7	12.1	Wf.
	3305.7	13.1	Wf.									
181136 W LYRAE—												
	3280.7	8.2	Wf.	3284.7	8.2	Wf.	3285.8	8.5	Sg.	3287.7	8.5	Pi.
	3287.7	8.4	Gd.	3288.8	8.4	Wf.	3289.7	8.9	Ct.	3290.7	9.0	Ct.
	3291.7	9.2	Ct.	3292.7	8.5	Pt.	3293.7	9.1	Ct.	3293.7	8.7	Wf.
	3295.7	9.3	Ct.	3297.9	8.9	Sg.	3303.7	9.4	Ct.	3305.7	9.3	Wf.
	3307.7	10.2	Ct.	3308.7	9.7	Ct.	3310.7	9.8	Ct.	3311.6	9.8	B.
	3311.7	9.6	Ct.	3312.8	10.0	Sg.	3313.7	10.0	Ct.	3314.7	9.7	Ct.
	3315.7	10.0	Ca.									
182224 SV HERCULIS—												
	3292.7	14.3	Pt.									
182306 T SERPENTIS—												
	3285.7	<11.0	Pw.	3292.7	12.0	Pt.						
183149 SV DRACONIS—												
	3262.4	9.4	Jp.	3262.4	9.3	Dp.						
183308 X OPHIUCHI—												
	3292.7	8.6	Pt.	3303.6	8.5	Gd.	3306.6	8.7	O.	3311.6	9.2	Cd.
	3315.6	9.0	Ya.									
184134 RY LYRAE—												
	3287.7	14.3	M.	3313.6	<10.6	Pw.						
184205 R SCUTI—												
	3259.0	5.5	Kd.	3268.4	5.8	An.	3276.4	5.4	Gi.	3277.0	5.4	Kd.
	3277.7	5.5	Jb.	3280.4	5.8	An.	3281.4	5.9	An.	3281.5	5.4	Ro.
	3282.0	5.5	Kd.	3282.4	5.8	An.	3282.7	5.3	Jb.	3283.5	5.4	Ro.
	3284.4	5.9	An.	3284.5	5.5	Gi.	3284.7	5.8	Br.	3285.0	5.5	Kd.
	3285.4	5.9	An.	3285.8	5.5	Sg.	3286.6	5.8	Pt.	3287.0	5.6	Kd.
	3287.4	5.9	An.	3287.5	5.4	Ro.	3287.7	5.5	Pt.	3288.6	5.9	Pt.
	3288.6	5.8	O.	3288.6	5.5	Su.	3289.7	5.5	Pt.	3289.7	5.7	Ct.
	3290.5	5.8	Ro.	3290.7	5.6	Ct.	3291.6	5.8	Ca.	3291.7	5.8	Br.
	3291.7	5.4	Ct.	3291.8	5.6	Jb.	3292.6	6.0	Pt.	3293.6	5.8	Ca.
	3293.7	5.7	Ct.	3294.4	5.9	Gi.	3294.5	5.5	Ro.	3294.7	6.1	Pt.
	3295.5	5.6	Ro.	3295.6	5.8	Ca.	3295.7	5.6	Ct.	3296.7	5.6	Ct.
	3297.6	5.8	Pt.	3298.6	5.9	Pt.	3299.7	5.7	Ct.	3302.5	6.1	Ca.
	3302.7	6.2	Sg.	3302.7	6.0	Br.	3303.6	6.4	Pt.	3303.7	5.7	Ct.
	3304.6	6.3	Pt.	3305.5	6.1	Cd.	3305.6	6.3	Pt.	3305.7	6.4	Br.

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
184205 R SCUTI—Continued.								
	3305.8	6.2 Ct,	3306.6	6.5 Pt,	3307.7	6.4 Ct,	3308.5	6.0 Ro,
	3308.6	6.7 Ct,	3308.6	6.8 O,	3308.6	6.3 Ca,	3309.6	6.3 Pt,
	3309.7	6.3 Ct,	3310.6	6.3 Pt,	3310.7	6.8 Ct,	3310.7	6.8 Br,
	3311.6	6.7 Ct,	3311.6	6.5 Pt,	3312.5	6.1 Ro,	3312.6	6.3 Pt,
	3313.6	6.7 Ct,	3313.6	6.4 Pt,	3314.7	6.8 Ct,	3315.6	6.9 Ya,
	3315.6	6.4 Pt,	3316.6	6.9 Hu,	3316.6	6.3 Pt,	3318.6	6.3 Ca.
184243 RW LYRAE—								
	3312.6	13.6 Pt.						
184300 NOVA AQUILAE #3—								
	3264.4	10.0 Jp,	3275.7	9.6 To,	3278.3	10.3 Jp,	3281.5	10.3 Ro,
	3281.7	9.9 To,	3283.5	10.4 Ro,	3284.5	10.0 Gi,	3285.5	10.3 Ro,
	3287.5	10.3 Ro,	3287.7	9.9 Sg,	3288.3	10.4 Jp,	3288.6	10.7 Pt,
	3291.6	10.1 Ca,	3293.5	10.3 Ro,	3293.7	9.8 To,	3294.5	10.3 Ro,
	3295.5	10.3 Ro,	3303.6	9.6 Pt,	3305.5	10.3 Ro,	3308.5	10.3 Ro,
	3308.7	10.0 Sg,	3309.6	10.1 Pt,	3312.5	10.2 Ro.		
185032 RX LYRAE—								
	3287.6	14.2 M,	3292.7	13.5 Pt.				
185634 Z LYRAE—								
	3300.7	10.0 Br.						
185737 RT LYRAE—								
	3264.3	11.0 Jp,	3289.4	12.8 Jp,	3300.7<11.1 Br.			
190108 R AQUILAE—								
	3264.4	7.1 Jp,	3289.4	9.1 Bp,	3292.7	7.5 Pt,	3296.4	9.3 Bp.
190907b TY AQUILAE—								
	3283.7	10.7 Br,	3292.7	10.3 Pt,	3307.7	10.9 Br.		
190925 S LYRAE—								
	3287.7	13.7 Gd,	3287.7	13.5 M,	3287.7	13.7 Pi.		
190926 X LYRAE—								
	3287.7	9.3 M,	3292.7	8.9 Pt.				
190933a RS LYRAE—								
	3307.7	11.8 Br.						
190941 RU LYRAE—								
	3264.3<12.6 Jp,		3278.3<12.6 Jp,		3288.4<12.6 Jp.			
190967 U DRACONIS—								
	3292.7	13.3 Pt,	3307.7	11.5 Br,	3313.6	11.9 Hu.		
191007 W AQUILAE—								
	3283.7<11.0 Br,		3292.7	12.8 Pt.	3307.7<11.8 Br.			
191017 T SAGITTARII—								
	3268.3	9.4 Jp,	3289.4	10.5 Jp.				
191019 R SAGITTARII—								
	3268.3	8.4 Jp,	3289.3	9.6 Bp,	3289.7<10.4 Ct,		3292.7	10.0 Pt,
	3293.6	10.1 Ca,	3296.3	9.8 Bp,	3307.7 <9.5 Ct,		3315.5	10.4 Ya,
	3318.5	11.0 Ca.						
191033 RY SAGITTARII—								
	3277.8	9.4 To,	3282.7	9.4 To,	3286.7	9.4 To,	3286.6	9.9 Pt,
	3287.7	10.2 Pt,	3288.6	10.0 Pt,	3292.7	9.8 Pt,	3293.7	9.5 To,
	3303.6	9.0 Pt,	3304.6	9.0 Pt,	3305.6	9.2 Pt,	3306.6	9.5 Pt,
	3309.6	9.0 Pt,	3310.6	9.1 Pt,	3311.6	9.0 Pt,	3312.6	9.5 Pt,
	3313.6	9.4 Pt,	3316.5	9.4 Ya,	3316.6	9.4 Pt.		
191319 S SAGITTARII—								
	3268.3<12.2 Jp,		3279.4<14.4 Gi,		3315.5<11.1 Ya,		3318.5<11.1 Ca.	
191321 Z SAGITTARII—								
	3279.4<13.7 Gi.							
191350 TZ CYGNI—								
	3264.3	10.3 Jp,	3280.4	10.4 Jp,	3292.7	10.5 Pt.		
191637 U LYRAE—								
	3292.7	10.6 Pt.						
192928 TY CYGNI—								
	3287.7	11.7 M.						

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
193311 RT AQUILAE—												
	3290.7	9.5	Br,	3292.7	9.8	Pt,	3306.6	10.0	O,	3311.7	10.0	Br.
193449 R CYGNI—												
	3264.4	8.8	Jp,	3279.7	9.4	Jb,	3282.7	9.8	Jb,	3288.6	9.0	Hu,
	3289.4	9.6	Jp,	3289.7	9.8	Sg,	3290.6	10.2	Gd,	3294.7	9.9	Br,
	3309.6	10.3	Pt,	3312.8	11.5	Sg,	3316.6	10.5	Ya.			
193509 RV AQUILAE—												
	3264.4	<13.0	Jp,	3290.7	<12.2	Br,	3293.7	<12.2	To,	3311.7	<12.2	Br.
193732 TT CYGNI—												
	3288.6	7.0	Hu,	3288.8	8.3	M.						
194048 RT CYGNI—												
	3269.4	6.8	Bp,	3269.4	6.9	Au,	3278.6	7.1	Gi,	3279.7	6.7	Jb,
	3281.4	6.9	Bp,	3282.7	6.7	Jb,	3288.6	7.0	Hu,	3289.7	7.8	Sg,
	3290.6	7.5	Gd,	3294.6	7.3	Gi,	3294.7	7.5	Br,	3295.5	7.2	Bp,
	3295.8	7.2	Jb,	3309.6	7.8	Pt,	3312.8	8.0	Sg,	3315.7	8.2	Ca.
194348 TU CYGNI—												
	3264.4	9.8	Jp,	3280.4	10.1	Jp,	3288.6	10.2	Hu,	3290.6	10.9	Gd,
	3294.7	11.1	Br,	3309.6	12.3	Pt.						
194604 X AQUILAE—												
	3283.8	14.5	Wf,	3290.7	14.5	Wf,	3307.8	<12.9	Wf.			
194632 χ CYGNI—												
	3264.4	8.3	Jp,	3275.7	7.3	To,	3285.0	6.7	Kd,	3287.1	6.6	Kd,
	3287.4	6.3	An,	3288.1	6.6	Kd,	3288.4	6.2	An,	3288.6	6.9	Hu,
	3288.6	6.3	Pt,	3288.8	6.8	M,	3289.7	6.1	Ct,	3290.4	5.9	An,
	3290.7	6.2	Ct,	3291.7	6.5	Ct,	3292.7	6.1	Pt,	3293.3	5.7	An,
	3293.7	5.8	Ct,	3294.7	6.0	Br,	3295.4	5.6	An,	3295.7	5.7	Ct,
	3296.7	5.7	Ct,	3298.3	5.3	An,	3299.7	5.4	Ct,	3300.7	6.0	Br,
	3302.7	5.4	Br,	3303.7	5.6	Ct,	3305.7	5.0	Br,	3305.8	5.3	Ct,
	3307.7	5.3	Ct,	3308.7	5.4	Ct,	3308.7	4.7	Ca,	3309.6	4.3	Pt,
	3309.7	5.2	Ct,	3310.7	4.9	Ct,	3310.7	4.8	Br,	3311.7	4.8	Ct,
	3313.7	4.8	Ct	3314.7	4.6	Ct.						
195203 RR AQUILAE—												
	3264.4	10.4	Jp,	3282.7	11.4	To,	3286.7	11.4	To,	3293.7	11.4	To,
	3309.6	11.8	Pt.									
195308 RS AQUILAE—												
	3264.4	9.6	Jp,	3275.7	9.0	To,	3280.4	8.7	Jp,	3282.7	8.5	To,
	3286.7	8.6	To,	3290.7	8.7	Br,	3293.7	8.9	To,	3296.6	9.0	Gd,
	3309.6	9.8	Pt,	3311.6	9.1	B.						
195653 NOVA CYGNI #3—												
	3264.4	11.2	Jp,	3264.4	10.9	Dp,	3285.5	10.5	Ro,	3287.7	10.4	Pt,
	3292.7	10.7	Pt,	3294.6	10.2	Gi,	3295.5	10.5	Ro,	3297.6	10.5	Pt,
	3303.6	10.5	Pt,	3305.5	10.1	Ro,	3305.6	10.5	Pt,	3309.6	10.2	Pt,
	3312.6	10.3	Pt,	3315.7	10.9	Pt,	3315.7	10.3	Ca.			
195849 Z CYGNI—												
	3268.3	10.9	Jp,	3278.6	11.7	Gi,	3283.8	12.4	Wf,	3290.8	12.7	Wf,
	3307.8	13.0	Wf,	3310.6	12.5	Pt.						
200212 SY AQUILAE—												
	3283.8	13.3	Wf,	3287.6	12.1	M,	3290.7	13.2	Wf,	3294.7	<11.8	Br,
	3307.8	13.3	Wf,	3311.7	<11.8	Br,	3313.6	<10.8	Pw.			
200357 S CYGNI—												
	3283.8	<14.7	Wf,	3290.8	<14.7	Wf,	3307.8	<14.3	Wf.			
200514 R CAPRICORNI—												
	3280.4	12.1	Jp,	3285.4	11.4	Gi,	3309.6	12.8	Pt,	3311.6	12.4	B.
200715a S AQUILAE—												
	3263.4	10.6	Au,	3263.4	10.6	Bp,	3268.5	11.1	Gi,	3269.4	10.4	Bp,
	3277.4	11.3	Bp,	3279.4	11.4	Gi,	3283.8	11.1	Wf,	3288.4	10.4	Bp,
	3288.7	11.3	Br,	3288.8	10.3	Wf,	3288.8	11.0	M,	3289.4	10.4	Gi,
	3293.7	9.8	Wf,	3294.4	10.1	Bp,	3296.6	9.9	Gd,	3305.8	9.5	Wf,
	3309.5	9.4	Gd,	3309.6	9.4	Pt,	3311.7	9.8	Br.			

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
200715b RW AQUILAE—												
	3288.8	9.2	M,	3309.6	9.4	Pt.	3311.7	9.2	Lc.			
200812 RU AQUILAE—												
	3291.7	12.9	Wf,	3294.6	12.8	B,	3307.8	13.2	Wf.			
200822 W CAPRICORNI—												
	3310.6	13.0	Pt.									
200906 Z AQUILAE—												
	3276.5	11.1	Gi,	3280.4	10.7	Jp,	3287.4	9.6	Gi,	3290.6	10.0	B,
	3293.6	10.2	Gd,	3307.7	10.2	Br,	3309.5	9.8	Gd,	3309.6	10.2	Pt.
200916 R SAGITTAE—												
	3288.8	9.4	M.									
200938 RS CYGNI—												
	3263.4	9.0	Au,	3263.4	8.9	Bp,	3286.4	8.7	Bp,	3288.7	7.7	Sg.
	3294.5	8.8	Bp,	3309.6	7.5	Pt,	3312.8	7.5	Sg.			
201008 R DELPHINI—												
	3275.5	9.4	Bp,	3282.4	9.7	Bp,	3288.5	9.9	Bp,	3291.7	9.6	Wf.
	3294.5	10.1	Bp,	3294.6	9.9	B,	3307.7	10.3	Br,	3307.8	10.8	Wf,
	3308.6	10.5	O,	3309.6	10.9	Pt.						
201121 RT CAPRICORNI—												
	3281.4	7.5	Bp,	3285.0	7.5	Kd,	3285.4	7.6	Bp,	3287.0	7.5	Kd,
	3294.4	7.6	Bp,	3310.6	6.6	Pt.						
201130 SX CYGNI—												
	3287.6	13.7	M,	3291.7	13.7	Wf,	3307.8	13.8	Wf.			
201139 RT SAGITTARII—												
	3309.6	12.5	Pt.									
201437b WX CYGNI—												
	3280.4	10.3	Jp,	3283.8	10.2	Wf,	3288.6	10.6	Pi,	3288.7	10.5	Sg,
	3288.8	10.6	Wf,	3293.7	10.4	Wf,	3294.7	10.6	Br,	3305.8	10.4	Wf.
	3306.5	10.5	Gd,	3307.8	10.6	Wf,	3309.6	10.7	Pt,	3311.7	10.3	Br.
	3312.8	10.5	Sg.									
201647 U CYGNI—												
	3261.4	8.2	Bp,	3267.4	8.2	Bp,	3267.4	8.2	Au,	3277.7	8.3	Jb.
	3281.5	10.0	Ro,	3282.7	8.3	Jb,	3283.5	9.5	Ro,	3285.3	9.2	Bp,
	3285.5	9.5	Ro,	3288.6	9.8	Pi,	3288.6	8.9	Gi,	3288.6	8.0	Hu.
	3288.8	9.3	M,	3290.5	9.3	Ro,	3291.8	8.4	Jb,	3292.5	9.8	Bp.
	3294.5	9.0	Ro,	3295.5	9.0	Ro,	3304.5	9.5	Ro,	3305.5	9.2	Ro.
	3307.7	9.2	Br,	3307.7	<9.8	Ct,	3309.6	8.4	Pt.	3312.5	9.5	Ro.
202539 RW CYGNI—												
	3288.8	9.0	M.									
202622 RU CAPRICORNI—												
	3276.5	9.4	Gi,	3287.4	9.8	Gi,	3294.7	10.2	B.			
202817 Z DELPHINI—												
	3291.7	14.2	Wf,	3308.7	14.4	Wf.						
202946 SZ CYGNI—												
	3288.8	9.2	M,	3288.6	8.9	Pt,	3297.6	9.5	Pt.	3309.6	9.5	Pt.
202954 ST CYGNI—												
	3283.8	13.2	Wf,	3288.6	<12.1	Pi,	3290.8	13.4	Wf,	3308.7	13.5	Wf.
203226 V VULPECULAE—												
	3288.8	8.7	M,	3309.6	8.7	Pt.						
203611 Y DELPHINI—												
	3288.4	<13.0	Jp,	3291.8	13.1	Wf,	3308.7	13.3	Wf.			
203816 S DELPHINI—												
	3307.7	10.0	Br,	3311.6	10.4	Gd.						
203847 V CYGNI—												
	3283.7	8.5	Br,	3283.8	8.5	Wf,	3285.6	9.5	Pc,	3288.6	8.2	Gi,
	3288.8	9.0	M,	3290.8	8.6	Wf,	3308.8	8.4	Wf,	3309.6	7.2	Pt.
203905 Y AQUARII—												
	3294.7	9.8	B,	3287.7	9.8	Sg,	3309.6	10.6	Pt.			
204016 T DELPHINI—												
	3283.8	14.3	Wf,	3287.6	14.3	M,	3290.8	14.2	Wf,	3307.8	12.5	Wf.
204102 V AQUARII—												
	3294.7	8.2	B,	3307.7	8.3	Br,	3309.6	8.2	Pt.			

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Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
204104 W AQUARII—												
	3284.5	12.3	Gi,	3290.7	12.4	B,	3296.4	12.7	Gi.			
204215 U CAPRICORNI—												
	3279.4	11.8	Gi,	3289.4	11.5	Gi,	3309.6	11.8	Pt.			
204318 V DELPHINI—												
	3285.4	<14.7	Gi,	3287.6	<14.5	M,	3291.8	<14.1	Wf,	3308.7	<14.0	Wf.
204405 T AQUARII—												
	3287.6	12.2	M,	3293.6	<11.0	Ca,	3295.5	11.5	Ro,	3307.7	<10.2	Ct.
	3307.8	11.4	Br,	3309.6	11.5	Pt,	3312.5	11.3	Ro,	3314.7	<9.8	Ct.
204846 RZ CYGNI—												
	3283.8	13.6	Wf,	3290.8	13.6	Wf,	3294.6	13.3	Gi,	3308.7	13.5	Wf,
	3309.6	13.5	Pt.									
205017 X DELPHINI—												
	3291.8	9.3	Wf,	3294.6	9.4	B,	3307.8	9.9	Br,	3308.6	10.4	O,
	3309.7	10.1	Wf,	3311.6	9.8	Gd.						
205923 R VULPECULAE—												
	3280.4	10.7	Gi,	3283.8	10.3	Wf,	3288.8	9.8	Wf,	3291.4	9.4	Gi,
	3293.7	9.3	Wf,	3301.8	8.9	Wf,	3307.8	7.7	Wf,	3307.8	7.8	Br,
	3308.7	8.0	Wf,	3309.6	8.0	Pt,	3310.6	8.2	B,	3313.6	8.3	Hu.
210124 V CAPRICORNI—												
	3276.5	9.2	Gi,	3287.4	9.0	Gi.						
210129 TW CYGNI—												
	3291.8	14.1	Wf,	3308.7	13.6	Wf.						
210221 X CAPRICORNI—												
	3276.5	10.2	Gi,	3287.4	11.1	Gi.						
210382 X CEPHEI—												
	3291.8	<14.2	Wf,	3308.8	<13.4	Wf.						
210504 RS AQUARII—												
	3288.4	10.8	Jp,	3294.6	11.7	B,	3307.8	<11.5	Br,	3309.6	12.1	Pt.
210516 Z CAPRICORNII—												
	3290.7	10.5	B,	3309.6	10.4	Pt.						
210812 R EQUULEI—												
	3291.8	14.5	Wf,	3308.7	<13.8	Wf.						
210868 T CEPHEI—												
	3261.4	7.8	Bp,	3267.4	7.8	Bp,	3267.4	8.1	Au,	3275.4	8.9	Bp,
	3283.4	9.0	Bp,	3286.7	8.0	Pt,	3287.6	8 8.	Ya,	3287.6	8.8	Cg,
	3288.4	8.5	Jp,	3288.6	9.1	O,	3289.5	9.2	Bp,	3295.4	9.4	Bp,
	3308.0	9.0	Br,	3311.6	9.5	Cg,	3314.6	9.2	Gd.			
210903 RR AQUARII—												
	3286.7	9.5	Pt.	3294.6	9.4	B.						
211614 X PEGASI—												
	3284.5	12.0	Gi,	3286.7	12.2	Pt.	3288.4	<12.7	Jp,	3291.8	11.4	Wf,
	3294.5	11.5	Gi,	3305.8	11.7	Wf,	3307.8	11.2	Br,	3308.7	11.6	Wf.
211615 T CAPRICORNI—												
	3286.7	13.5	Pt.									
212814 Y CAPRICORNI—												
	3286.7	13.5	Pt.									
213244 W CYGNI—												
	3259.1	6.5	Kd,	3277.0	6.5	Kd,	3280.4	6.7	An,	3283.0	6.6	Kd,
	3285.0	6.5	Kd,	3287.0	6.5	Kd,	3290.4	6.7	An.			
213678 S CEPHEI—												
	3286.4	8.6	Bp,	3286.7	7.6	Pt,	3288.5	8.9	Bp,	3291.8	8.4	Wf,
	3292.4	8.9	Bp,	3298.4	8.2	Gi,	3308.0	8.0	Br,	3308.7	7.4	Wf,
	3313.6	7.9	Hu.									
213753 RU CYGNI—												
	3288.6	8.4	Pi,	3288.6	8.3	Pt.						
213843 SS CYGNI—												
	3236.4	8.8	Jp,	3236.4	8.8	Dp,	3240.4	8.8	Jp,	3241.3	9.1	Jp,
	3243.3	9.8	Jp,	3246.3	10.9	Jp,	3250.4	11.8	Jp,	3250 4	11.7	Dp,
	3257.4	12.0	Jp,	3260.4	11.9	Jp,	3260.4	12.0	Dp,	3262.4	11.9	Jp,
	3262.4	11.9	Dp,	3264.4	11.9	Jp,	3264.4	11.9	Dp,	3267.4	11.9	Jp,

VARIABLE STAR OBSERVATIONS, August 20 to September 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213843 SS CYGNI—Continued.												
	3268.3	11.9	Jp,	3268.4	12.0	Gi,	3270.3	12.0	Jp,	3270.3	11.9	Dp,
	3271.4	11.7	Jp,	3271.4	11.6	Dp,	3272.3	11.6	Jp,	3272.3	11.7	Dp,
	3274.4	11.7	Jp,	3275.4	11.9	Jp,	3275.7	11.3	To,	3276.4	11.7	Jp,
	3276.4	11.9	Gi,	3277.4	11.6	Gi,	3278.3	11.8	Jp,	3278.4	11.6	Gi,
	3279.4	11.5	Gi,	3280.3	11.6	Jp,	3280.4	11.5	Gi,	3280.7	11.9	Wf,
	3280.7	11.8	Br,	3281.4	11.8	Gi,	3281.5	11.6	Jp,	3281.5	11.6	Dp,
	3281.5	11.6	Ro,	3281.7	11.8	Wf,	3282.3	11.6	Jp,	3283.3	11.6	Jp,
	3283.3	11.6	Dp,	3283.7	11.8	Br,	3283.8	11.7	Wf,	3284.3	11.6	Jp,
	3284.3	11.6	Dp,	3284.4	11.6	Gi,	3284.8	11.7	Wf,	3285.3	11.6	Jp,
	3285.4	11.5	Gi,	3285.5	11.6	Ro,	3285.6	11.7	Pc,	3285.7	11.7	Wf,
	3286.3	11.6	Jp,	3286.3	11.6	Dp,	3286.4	11.7	Gi,	3286.7	12.4	Sg,
	3286.7	12.0	To,	3286.7	11.8	Pt,	3287.4	12.0	Gi,	3287.5	11.9	Jp,
	3287.5	11.9	Dp,	3287.6	11.9	Gd,	3287.6	11.9	Pi,	3287.6<11.3		Ya,
	3287.6<10.0		O,	3287.6	12.0	B,	3287.7	12.0	Wf,	3287.7	11.9	Pt,
	3288.4	12.0	Jp,	3288.6	12.0	Gi,	3288.6	11.9	Pt,	3288.6	11.9	Gd,
	3288.6<10.0		O,	3288.6	11.9	Pi,	3288.6	11.6	Hu,	3288.7	11.9	Br,
	3288.8	12.1	Wf,	3288.8	12.0	M,	3289.3	12.0	Gi,	3289.4	11.9	Jp,
	3289.6	11.9	Pi,	3289.6<11.2		Ya,	3289.6	11.9	Gd,	3290.4	12.0	Gi,
	3290.4	11.7	Jp,	3290.6<11.3		Pi,	3290.6	11.9	Gd,	3290.7	11.9	Br,
	3290.8	11.9	Wf,	3291.4	12.0	Gi,	3291.4	11.9	Jp,	3291.4	11.8	Dp,
	3291.6	11.9	Gd,	3291.8	11.9	Wf,	3292.3	11.7	Jp,	3292.7	11.6	Pt,
	3292.7	12.1	Wf,	3293.3	12.0	Gi,	3293.6<11.2		Ya,	3293.6	11.9	Gd,
	3293.7<11.8		Br,	3293.7	11.9	Wf,	3294.3	12.0	Gi,	3294.6	11.9	B,
	3294.7	11.8	Wf,	3294.7<10.9		Br,	3294.7	11.6	Pt,	3295.5	11.9	Gd,
	3295.5	11.6	Ro,	3295.6	12.0	Gi,	3295.7	11.9	Wf,	3296.5	11.9	Gd,
	3296.6	12.0	Gi,	3296.7<10.9		Br,	3296.7	12.0	Wf,	3297.5	11.9	Gd,
	3297.6	11.9	Pt,	3297.9	12.0	Sg,	3298.3	12.0	Gi,	3298.6	11.9	Pt,
	3300.5	11.9	Gd,	3300.5	8.7	Ca,	3300.7<10.9		Br,	3301.8	11.9	Wf,
	3302.5	11.9	Gd,	3303.5	11.9	Gd,	3303.6	11.9	Pt,	3304.5	11.6	Ro,
	3304.6	11.9	Pt,	3305.5	9.3	Gd,	3305.5	9.4	Ro,	3305.5	9.5	Pt,
	3305.7	8.9	Pt,	3305.8	8.8	Wf,	3306.5	8.4	Ro,	3306.5	8.3	Gd,
	3306.6	8.4	Ya,	3306.6<10.0		O,	3306.6	8.2	Pt,	3307.7	8.6	Br,
	3307.7	10.8	Ca,	3307.8	8.4	Wf,	3307.8	8.6	Br,	3308.0	8.6	Br,
	3308.6	8.3	O,	3308.7	8.8	Wf,	3308.7	8.6	Br,	3309.6	9.0	Pt,
	3309.7	8.8	Br,	3310.6	9.4	Pt,	3310.6	9.1	B,	3310.7	9.2	Br,
	3311.6	9.5	Pt,	3311.6	9.5	Br,	3311.6	9.4	B,	3311.6	9.2	O,
	3312.5	9.8	Ro,	3312.6	9.9	Pt,	3312.8	9.5	Sg,	3313.5	9.9	Ya,
	3313.6	10.2	Hu,	3313.6	10.2	Pt,	3314.8	10.5	Pt,	3315.6	11.0	Pi,
	3315.7	11.2	Pt,	3316.6	11.6	Hu,	3316.6	11.7	Pt.			
213937 RV CYGNI—												
	3288.6	6.4	Pt,	3313.6	7.0	Hu.						
214024 RR PEGASI—												
	3288.4<13.0		Jp,	3288.6	13.5	Pt,	3291.8	14.0	Wf,	3308.7	13.2	Wf.
215605 Y PEGASI—												
	3288.6<10.8		Pw,	3288.6	12.2	Pt,	3291.8	12.4	Wf,	3307.8	11.0	Br,
	3308.7	11.0	Wf.									
215717 U AQUARII—												
	3292.7	12.0	Pt,	3310.6	11.6	B.						
215934 RT PEGASI—												
	3292.7	11.1	Pt,	3307.8	11.2	Br.						
220133a RY PEGASI—												
	3310.6	9.0	Pt.									
220133b RZ PEGASI—												
	3283.7<11.9		Br,	3307.8	9.6	Br.						
220412 T PEGASI—												
	3280.5	12.1	Gi,	3296.4	12.9	Gi,	3307.8<11.5		Br.			
220613 Y PEGASI—												
	3288.7<12.5		Br,	3290.7	14.0	B,	3291.4<14.8		Gi,	3308.6<12.5		O.
220714 RS PEGASI—												
	3280.4	9.6	Gi,	3286.4	9.6	Bp,	3288.7	9.5	Br,	3290.7	9.9	B,
	3291.4	9.6	Gi,	3292.4	9.9	Bp,	3308.6	10.5	O.			

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Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
222439 S LACERTAE—												
	3280.4	12.4	Gi,	3289.6	<11.6	Pi,	3294.4	12.7	Gi,	3310.6	13.2	Pt.
223841 R LACERTAE—												
	3280.4	10.5	Gi,	3294.4	11.6	Gi.						
225914 RW PEGASI—												
	3290.8	11.5	Sg,	3307.8	<11.7	Br,	3312.9	<11.2	Sg.			
230110 R PEGASI—												
	3282.7	11.	To,	3293.8	<12.4	To,	3308.5	12.4	Ro,	3310.6	12.8	Pt,
	3312.5	12.4	Ro.									
230759 V CASSIOPEIAE—												
	3260.4	10.5	Bp,	3267.4	10.2	Au,	3267.4	10.2	Bp,	3278.5	9.7	Gi,
	3281.4	9.5	Bp,	3281.5	9.8	Ro,	3283.5	9.6	Ro,	3285.4	9.4	Bp,
	3287.5	9.6	Ro,	3289.6	9.4	Pi,	3290.4	8.7	Gi,	3290.5	9.6	Ro,
	3291.4	9.3	Bp,	3294.5	9.4	Ro,	3295.5	9.3	Ro,	3305.5	8.3	Ro,
	3308.5	8.0	Ro,	3310.6	7.4	Pt,	3312.5	7.8	Ro,	3314.6	7.8	Gd.
231508 S PEGASI—												
	3310.6	11.8	Pt.									
233335 ST ANDROMEDAE—												
	3280.7	10.7	Wf,	3288.8	10.9	Wf,	3290.7	10.7	Br,	3308.7	11.1	Wf,
	3310.6	10.9	Pt,	3313.6	10.6	Hu.						
233815 R AQUARII—												
	3286.8	9.5	To,	3288.7	9.5	Cd,	3283.7	9.7	Ca,	3293.8	8.9	Jb,
	3310.6	9.6	Pt,	3316.6	9.6	Cd.						
233956 Z CASSIOPEIAE—												
	3280.7	<14.0	Wf,	3283.8	14.2	Wf,	3290.8	14.4	Wf,	3308.7	<13.4	Wf.
235053 RR CASSIOPEIAE—												
	3285.4	14.0	Gi.									
235209 V CETI—												
	3296.5	<14.4	Gi.									
235350 R CASSIOPEIAE—												
	3278.5	11.5	Gi,	3291.4	11.1	Gi.						
235525 Z PEGASI—												
	3310.6	13.1	Pt.									
235715 W CETI—												
	3296.5	14.4	Gi.									
235855 Y CASSIOPEIAE—												
	3285.4	14.4	Gi.									
235939 SV ANDROMEDAE—												
	3308.6	10.3	O,	3310.6	10.0	Pt.						

Total Observations: 1,734. Stars Observed: 259. Observers: 30.

after a very profitable six months spent in Arequipa, Peru, where, incidentally, she picked up another interesting nova at a stage where she was able to secure timely photographs of its spectrum.

Mention should be made of the specially fine lists of Messrs. Peltier and Waterfield included herewith. The following observers contributed to this report: Messrs. Ancarani "An" 3, Aurino "Au" 6, Bemporad "Bp" 6, Bouton "B" 6, Brocchi "Br" 6, Carr "Ca" 3, Chandler "Cd" 3, Christie "Ct" 2, Miss Clough "Cg" 3, Ginori "Gi" 9, Godfrey "Gd" 8r, Hunter "Hu" 8, Jacobsen "Jb" 5, Kanda "Kd" 2, Lacchini "L" 5, Lacy "Lc" 4, McAteer "M" 5 and 13, Olcott "O" 5, Dr. Paraskevopoulos "Jp" 16, Mrs. Paraskevopoulos "Dp" 16, Peltier "Pt" 6, Pickering "Pi" 8r and 3, Proctor "Pc" 12, Rhorer "Ro" 5, Skaggs "Sg" 5, Suter "Su" 4, Townley "To" 5, Waterfield "Wf" 12r, Watson "Pw" 6, and Yalden "Ya" 4.

The annual report is appended herewith, as well as a summary of annual reports.

HOWARD O. EATON, Recording Secretary.

ANNUAL REPORT OF THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS, 1921-1922.

Observer	Initial	November	December	January	February	March	April	May	June	July	August	September	October	Totals
Ancarani, M.	An	...	...	...	29	11	26	20	12	...	6	21	25	150
Aurino, S.	Au	19	...	...	...	...	...	...	...	...	11	7	11	48
Bemporad, A.	Bp	27	...	...	...	...	...	...	...	...	8	...	66	101
Bouton, T. C.	B	96	116	141	136	103	123	124	91	34	...	18	31	1013
Brocchi, D. F.	Br	3	13	16	61	45	58	85	38	70	133	...	120	642
Bunch, S.	Bh	31	33	...	...	...	...	10	...	...	...	...	...	74
Carr, F. J.	Ca	83	81	...	...	...	...	...	...	...	...	...	45	209
Chandler, F. H.	Cd	...	...	...	...	...	...	...	4	8	10	12	8	42
Chandra, R. G.	Ch	50	65	81	69	...	56	...	77	74	119	106	...	697
Christie, W. H.	Ct	...	...	...	...	...	...	...	...	...	...	18	104	122
Clement, W.	Cl	...	12	...	...	...	...	...	8	...	7	7	...	34
Clough, I. L.	Cg	9	8	6	7	...	...	5	...	...	6	24	18	83
Farnsworth, A.	Fn	...	...	...	...	12	16	...	2	...	...	8	...	38
Ginori, N. V.	Gi	145	145	101	77	71	73	49	40	104	98	140	126	1169
Godfrey, C.	Gd	51	2	5	...	...	...	3	3	15	15	...	57	151
Hoerl, J.	Hj	32	30	21	24	29	...	...	20	45	52	66	...	319
Hunter, S. C.	Hu	14	21	20	27	...	10	11	12	7	...	...	17	139
Jacobsen, T. S.	Jb	...	...	...	...	...	14	19	26	35	...	14	17	125
Jewell, W. R.	Je	...	...	...	3	2	19	...	3	...	...	...	...	27
Kanda, S.	Kd	...	...	...	25	31	35	25	22	10	26	42	19	235
Lacchini, G.	L	149	307	116	261	130	160	204	81	149	96	72	131	1856
Lacy, H. J.	Lc	14	14	7	...	10	...	...	...	10	...	12	5	72
Leavenworth, F. P.	Lv	...	11	9	24	33	25	14	26	37	...	27	...	206
Macaughey, E.	Mc	...	...	...	...	5	5	10	2	4	...	3	...	29
McAteer, C. Y.	M	177	30	9	38	31	...	132	95	147	133	101	32	925
Morris, Mrs. M.	Ms	38	14	...	24	13	7	...	...	...	...	...	...	96
Mundt, Carlos	Mu	52	59	30	13	28	...	29	52	67	86	...	...	416
Nakamura, K.	Nk	...	...	...	...	...	...	...	...	...	116	71	...	187
Olcott, W. T.	O	28	32	40	23	12	...	...	5	43	27	28	33	271
Paraskevopoulos, Dr. J. S.	Jp	...	...	...	...	...	24	43	78	48	96	...	108	397
Paraskevopoulos, Mrs. D.	Dp	...	...	...	...	...	18	29	78	48	97	...	17	287
Parkhurst, J. A.	Pa	...	...	...	...	...	...	...	...	...	21	33	...	54
Peltier, L.	Pt	166	159	134	166	188	186	188	210	217	198	251	271	2334
de Perrot, Ed.	Pe	75	30	...	11	...	...	...	12	...	52	...	...	180
Pickering, D. B.	Pi	...	...	...	14	56	16	...	...	...	...	...	21	107
Proctor, S. K.	Pc	63	22	...	...	16	27	39	37	30	35	...	6	275
Reesinck, K. O.	Rk	16	19	33	36	18	33	35	...	...	...	...	...	190
Rhorer, S. L.	Ro	18	...	35	...	...	...	27	17	6	...	14	69	186
Skaggs, J. H.	Sg	...	...	...	...	11	24	52	45	47	46	73	75	373
Suter, R. O.	Su	4	17	...	7	12	...	16	11	37	17	26	5	152
Townley, S. D.	To	13	29	...	53	...	21	...	...	13	63	...	37	229
Vrooman, H. W.	V	14	15	...	19	13	9	...	...	...	...	16	...	86
Waldo, G.	Wl	25	...	...	...	10	...	...	16	...	34	...	...	85
Waterfield, W. F. H.	Wf	136	68	...	64	92	157	149	149	190	106	110	223	1444
Watson, P. S.	Pw	...	...	...	...	...	6	10	...	10	9	6	15	56
Valden, J. E. G.	Ya	30	5	21	24	15	...	35	25	17	...	12	22	206
Yamamoto, I.	Ym	...	...	22	105	...	114	...	32	58	...	...	...	331
Young, Miss A. S.	Y	39	47	49	24	25	13	26	40	36	...	...	...	299
24 others		13	80	38	45	13	...	...	68	...	3	14	...	274
Total observations		1630	1484	934	1409	1035	1275	1389	1437	1616	1726	1352	1734	17021
Observers		31	33	23	29	31	27	27	44	30	30	32	30	72
Stars observed		293	245	249	249	232	240	237	307		305		259	372

SUMMARY OF ANNUAL REPORTS.

Year	Observations	Stars	Observers
1912	6180	175	19
1913	12914	200	20
1914	14506	255	28
1915	14724	282	29
1916	11261	290	30
1917	15788	332	43
1918	16112	380	34
1919	8710	352	53
1920	9099	395	69
1921	15513	386	77
1922	17021	372	72
	141828		

COMET AND ASTEROID NOTES.

New Comet *c* 1922 (Baade). — A new comet was discovered by Baade at Bergedorf, Germany, on October 19. It is a small comet, variously estimated at from ninth to eleventh magnitude, and so is not visible without a telescope. In fact it is scarcely visible with the 5-inch finder of the telescope at Northfield. The comet is in the Milky Way, in the constellation Cygnus, and moving rather slowly southeast. Its motion during November will carry it through Vulpecula into the western part of Pegasus.

The following are all of the observations which have come to hand. No ephemeris has yet been received.

OBSERVATIONS OF COMET *c* 1922 (BAADE).

Date, G. M. T.	Right Ascension	Declination	Observer	Place
	h m s	° ′ ″		
Oct. 22.3442	19 52 57.7	+36 57 38	Strömgren	Copenhagen
23.2803	19 55 02.3	+36 41 32	Strömgren	Copenhagen
24.6116	19 58 02.0	+36 18 35	Wilson	Northfield
24.6360	19 58 04.6	+36 18 07	Newbauer	Mt. Hamilton
25.6632	20 00 23.9	+36 00 25	Wilson	Northfield
26.5979	20 02 31.8	+35 44 12	Wilson	Northfield

Comet 1853 III (Klinkerfues).—This comet is of particular interest because it is one of the few comets whose orbits during the period of observation are hyperbolas. We have just received from *Astronomische Nachrichten* a new discussion of the orbit of this comet by Hermann Büttner. He finds that after making allowance for the perturbations of Jupiter, Saturn, Earth, and Venus the original orbit was an extremely long ellipse.

The Minor Planet 932 (1920 GV) Hooveria.—In a recent letter, Dr. Johann Palisa of the Vienna Observatory, Austria, wishes American astronomers to know of the action taken by the Senate of the University of Vienna in naming a minor planet (which, we may add, was recently discovered by Palisa) after Mr. Herbert Hoover in grateful recognition of his service to the Austrian people in their time of greatest need. This announcement will be found in *Astronomische Nachrichten*, No. 5172, page 192, a translation of which follows:

As a permanent memorial of the great help rendered to the people of Austria, and in particular to the officers of the higher institutions of learning

in Vienna, which was organized by Mr. Herbert Hoover (now Secretary of Commerce of the United States) the Academic Senate of the University of Vienna has named the minor planet 932 (1920 GV), *Hooveria.*

Palisa has been on the retired list since 1919. He is still active, however, in the work of the Vienna Observatory as is shown by his numerous observations printed in the *Astronomische Nachrichten.*

E. E. B.

COMMUNICATIONS.

The Friction of the Gyroscope.—In his article in the August-September number of "Popular Astromony" entitled "The Friction of the Gyroscope", Mr. Mott-Smith says:

"According to our theory then the sinking of the axle is not a gradual succumbing to the force of gravity. It is a second precession induced by the torque of the Z friction. It follows that if Z friction could be entirely removed, the axle would precess strictly horizontally despite the down pressure of the weight *however low the spin.* The deduction seems incredible, yet it is precisely what we intend to show".

The reason why the deduction *seems* "incredible" is that it *is* "incredible". The explanation of the sinking of the axle when precession is prevented is that the force stored in the spinning wheel is not then opposed to the force of gravity. It is released against gravity by precession. A rapidly spinning top will fall to the ground from a height just as it would do if it were not spinning, but its contained force *applied against gravity* will cause it to ascend.

Gravity is the *occasion*, not the *cause* of precession. It tilts the axle and thereby *releases* spin-force which produces precession. Precession in turn releases spin-force *against gravity* and if such force be sufficiently strong it will prevent the axle from falling at once. Stopping precession shuts off the flow of spin-force against gravity and the axle drops. The removal of Z friction resulting in increased precession and a larger flow of spin-force against gravity prolongs the contest between the two forces, but at length the spin-force becomes too feeble to sustain the weight even under the stimulation of external force applied to increase precession.

Consider a rotating upright wheel turned so quickly to a horizontal position that its rotation during such time is practically *nil;* the effect of such tilting is that the force stored in the wheel is applied so as to cause rotation around a new axis at right angles (practically) to the original axis—in other words, the entire spin-force is consumed in the generation of *precession.* Without tilting of the wheel precession cannot occur.

Mr. Mott-Smith says that "if the theory breaks down anywhere it is not until the last fraction of a turn". But if the theory were sound it would not break down *anywhere. It is* proved to be unsound by the fact that if the rotation of the wheel be extremely slow the axle will fall at once *without* friction and *with* hurried precession. It falls because the spin-force opposed to gravity is insufficient to sustain it. But despite this obvious fact Mr. Mott-Smith draws the "conclusion that if the precession were completely unopposed the axle would not sink at all", and "asserts that the torque of the weight" does not cause the axle to sink but that it "produces a *horizontal* rotation of the axle"—an "incredible" proposition repugnant to common sense and refuted by experiment. If the force of gravity be increased by the use of a heavier weight and increases of Z fric-

tion be prevented by means of ball-bearings the descent of the axle will be quicker.

The trouble with Mr. Mott-Smith's claimed experimental verification of the "frictionless" theory is that in attempting to turn the Z ring to "keep exact pace" with the Y ring he moves the latter just enough to maintain the axle at the horizontal while there is abundant spin-force in the wheel; but when this force is nearly all spent the axle will sink no matter how much the precession is hurried. Gravity is stronger than all of the opposed spin-force remaining in the wheel.

The sinking of the axle is not "a second precession induced by the torque of the Z friction". Z *friction* is not a "torque". It applies no force, it generates no motion. Annul gravity and no precession or other motion will ensue. The sinking of the axle is not a *precessional* motion; it is caused directly by the force of gravity.

August 20, 1922. L. A. REDMAN.

The Occultation of Aldebaran.—The following observations of the occultation of Aldebaran were made at the Roe Observatory on the morning of September 13:

Disappearance	Estimated	Observed
	d h m	d h m s
G. M.T., Sept.	12 23 53	12 23 50 53
Position Angle	116°	113°
Reappearance		
	d h m	d h m s
G. M. T., Sept.	13 1 1	13 1 1 38
Position Angle	235°	234°.5

The observations were made with the 6½ in. Clark refractor and Gaertner micrometer, a chronometer and chronograph watch. The estimates were made from the map published by Prof. Rigge in POPULAR ASTRONOMY. No calculations were made. The time was observed with a chronometer and chronograph watch, the second hand of the latter being started, from the chronometer, exactly four minutes and seven minutes before the estimated times. The position angles are the ordinary ones used in double star work. There was no uncertainty in the observation. The only slight uncertainty might have been in the time of the chronometer. The occultation, occurring at 6:51 with the sun rising at 5:36 E. S. T. and shining fully, was a beautiful sight in the telescope, especially the reappearance with the sudden flashing out of the star in the field of the telescope beyond the illuminated portion of the moon, close to the spider thread which had been set in anticipation at the expected point of reappearance.

E. D. ROE, JR.

Roe Observatory, 17 October, 1922.

GENERAL NOTES.

Dr. Knut Lundmark of Upsala, Sweden, who has been at the Lick Observatory as a Martin Kellogg fellow for a year is now at the Mount Wilson Observatory. Dr. Lundmark will remain at the Mount Wilson Observatory until the end of the year or longer if his leave of absence from Upsala is extended.

Mr. Richard Hawley Tucker, astronomer at the Lick Observatory, received the degree of Doctor of Science from his alma mater, Lehigh University, on the occasion of the installation of the new president of that University, on October 14, 1922.

Professor P. J. van Rhijn has been appointed director of the Astronomical Laboratory at Groningen, in succession to the late Professor J. C. Kapteyn.

Dr. Harlow Shapley, director of the Harvard College Observatory, lectured at Mount Holyoke College on October 6 on "Measuring the Milky Way." The lecture is the first of a series of science lectures provided for by the Polly Hollingsworth fund for lectures on art, science and music.—(*Science*, Oct. 13.)

Professor J. H. Jeans, secretary of the Royal Society, who was professor of applied mathematics at Princeton University from 1905 to 1909, received the doctorate of science from Oxford University on the occasion of his delivery of the Halley lecture.—(*Science*, Oct. 6.)

Professor E. T. Whittaker, formerly royal astronomer for Ireland and secretary of the Royal Astronomical Society, has been elected a foreign member of the Reale Accademia dei Lincei.—(*Science*, Oct. 6.)

Dr. Ludwik Silberstein, mathematical physicist at the Eastman Kodak Company Research Laboratory, has been appointed a member of the Commission on Relativity of the International Astronomical Union.—(*Science*, Oct. 13.)

Dr. Inigues, professor of astronomy at the University of Madrid and formerly director of the Madrid Observatory, has died.—(*Science*, Oct. 13.)

Professor H. Battermann, formerly professor of astronomy and director of the University Observatory at Königsberg, died on June 15, 1922, at the age of 62.

Professor C. Michie Smith, government astronomer of Madras, 1891-1911, and director of the Kodaikanal and Madras Observatories, 1899-1911, died on Sept. 27, 1922.

The Norman Lockyer Observatory, Sidmouth, England, has elected Dr. Otto Klotz, chief astronomer and director of the Dominion Astronomical Observatory, Ottawa, an honorary overseas member.—(*Science*, Oct. 13.)

The Perkins Observatory of the Ohio Wesleyan University.—The following note from Professor C. C. Crump should have appeared in our September issue, but was unfortunately mislaid.

A contract has been awarded to the Warner and Swasey Company of Cleveland, Ohio, for the construction of a 61-inch reflecting telescope for the Perkins Observatory of Ohio Wesleyan University. The telescope is to be of the Casse-

grain type and is to be mounted in a manner similar to that of the Ann Arbor and Victoria reflectors. The optical parts are to be figured by the John A. Brashear Company of Pittsburgh. The telescope is purchased from a fund given by Professor Hiram M. Perkins, who for more than fifty years was an instructor in Mathematics and Astronomy at the Ohio Wesleyan University. According to the terms of the gift the telescope is to be used for the instruction of students and the public, and for scientific research.

Lowell Institute Free Public Lectures. — The following is an interesting program of lectures to be given by Dr. Harlow Shapley, director of Harvard College Observatory, in the Lowell Institute, 491 Boylston Street, Boston. The Lowell Institute was founded by John Lowell, Jr., in 1836.

The general subject of the course of lectures is "The Content and Structure of the Sidereal Universe."

1. The Problems of Modern Astronomy, October 24.
2. Space, Time and Starlight, October 27.
3. Stars and Atoms, October 31.
4. Stellar Variation and Evolution, November 3.
5. Measuring the Milky Way, November 7.
6. Nebulae and Island Universes, November 10.
7. Origin of the Earth, November 14.
8. Life and the Physical Universe, November 17.

The Total Solar Eclipse of September 21. — Dr. A. C. D. Crommelin, writing in *Nature*, says that the failure of the Christmas Island eclipse expedition is a great astronomical disappointment. Messrs. Jones and Melotte have devoted ten months or more to it, and hoped to secure useful photometric results for connecting the northern and southern stellar magnitude scales in addition to the eclipse work. The climate, however, proved unexpectedly unfavorable, and practically nothing could be done.

On the other hand, the conditions appear to have been ideal right across Australia, and enthusiastic reports have come from Wollal (West Coast), Cordillo Downs (center) and Goondiwindi and Stanthorpe (Queensland). The Einstein problem was studied at Wollal by the Lick Observatory party under Professor Campbell, and that from Toronto under Professor Chant. Mr. Evershed also finally selected this station in preference to the Maldives, and is believed to have undertaken the same investigation, in addition, doubtless, to spectroscopic work. Professor Dodwell, the government astronomer at Adelaide, had the use at Cordillo Downs of a tower telescope lent by the Lick Observatory for the Einstein problem; the New South Wales astronomers were in Queensland and did some spectroscopic work; they intended also to make Einstein investigations, but the telegrams do not allude to these.

It is well to point out that the test of the Einstein theory does not depend wholly on the results of this eclipse. The plates secured in the 1919 eclipse at Principe and Sobral settled definitely that at least the half-shift was present, while the two cameras with the best definition gave values very close to the Einstein value. Further, the star-field in that eclipse was the best along the whole extent of the ecliptic, the stars in the present eclipse being much fainter. There are, however, two circumstances that should add weight to this eclipse: (1) that some of the observers were pointing directly on the stars, avoiding the use of a

cœlostat or other mirror; (2) that the plan was being tried of photographing another star-field *during totality*, thus obtaining an independent scale-value for the plates, which gives a much larger coefficient to the Einstein displacement in the equations of condition.

Probably weeks or months must elapse before the Einstein results are to hand. The corona is said to have had four long streamers, one extending to three solar diameters, which is more than the average, though by no means a record. Professor Chant reports that the shadow bands were photographed. Professor Kerr Grant, of Adelaide University, made measures at Cordillo by the photo-electric cell of the relative brightness of the sun and the corona. The results with this very sensitive instrument, should be more trustworthy than previous determinations.

The next two total eclipses (1923, September, and 1925, January) are visible in the United States; 1926, January, in Sumatra, etc., and 1927 in England and Norway.—(*Science*, October 20.)

The Structure of the Sidereal System.—From the days of Sir William Herschel to the present time various efforts have been made to determine the form and extent of the systems of stars within whose boundaries we find ourselves. The method employed is to count the stars of various magnitudes in selected regions of the sky, form an analytical expression from the numbers so obtained which will give the number of stars within a unit cube at varying distances from the sun and on the basis of this compute results for the regions lying beyond the stars used. Results of this sort have been published in recent

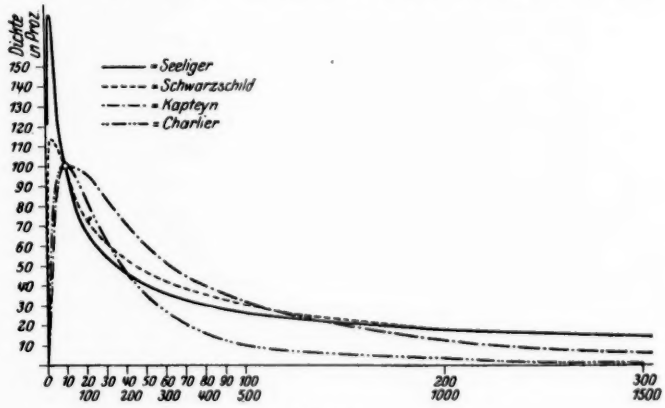

FIG. 1.

years by von Seeliger, Charlier, Schwarzschild, and Kapteyn and van Rhijn. The formulae obtained by these workers have been quite different in form but in an article by Dr. Hans Kienle of Munich for the issue of "Die Naturwissenschaften" for Aug. 11, 1922, he has reduced the results to a common basis and drawn curves which makes a comparison very easy. Some of these curves are reproduced here. The unit of distance used is the "Siriusweite" which is defined as the distance equivalent to an annual parallax of 0".20. This unit equals five parsecs or 16.3 light years.

Figure 1 shows the results of the four investigations where distances from the sun are the abscissas and relative star densities the ordinates. In this figure only average results are shown, no preference being given to any reference plane. It is seen that except in the region close to the sun the curves are not very different and that all agree that by the time we reach a distance of 1500 parsecs or about 5000 light years from the sun the number of stars per unit of space is very much less than in the neighborhood of the sun.

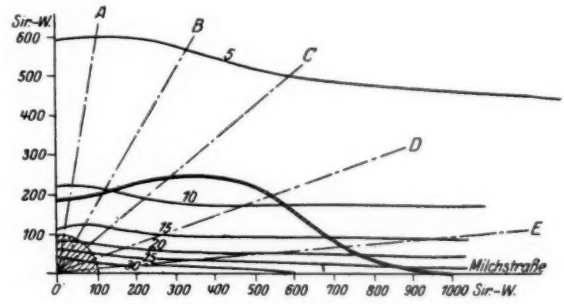

FIG. 2.

Figure 2 shows von Seeliger's results when he discusses the relation of star density to the Milky Way. The figure shows a section through the Milky Way perpendicular to its plane. In this case horizontal distances lie in the plane of the galaxy and vertical distances in the direction of the galactic poles. The curves drawn join points of equal star density.

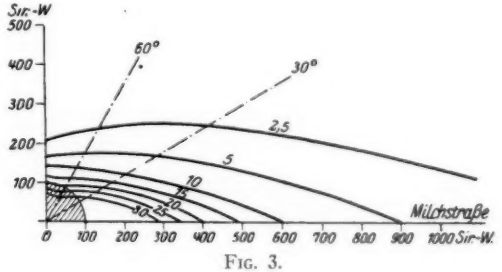

FIG. 3.

Figure 3 shows a similar figure for the results published by Kapteyn and van Rhijn.

In summing up the results of these various investigations Dr. Kienle draws the following conclusions:

1. The sun lies between 150 and 300 light years distant from the region of greatest star density.

2. The absolute value of the density at the center is somewhat uncertain but may be placed at from 10 to 20 stars within a cube measuring about 16 light years on a side.

3. The various formulae used by the different investigators agree in finding

a density of between 5 and 10 per cent of the central density when we reach a distance of 8000 light years.

4. The decrease in star density in the direction of the Milky Way is much less rapid than in a direction at right angles to it. The limits of the system in the latter direction are about 3000 light years distant, while in the former they are to be found about 15000 light years away.

5. As seen from without the stellar system would appear lens-shaped, with its greatest dimensions in the Milky Way and its thickness about one fifth of its diameter.

New Globular Clusters. — With the hope of adding to the list of globular clusters, we have recently studied on Harvard photographs a number of suspected objects. Of those listed below, four are new globular clusters not included in the earlier lists given by the writer in Mount Wilson Contributions 152 and 161. They are N. G. C. 6139 and 6342, found at Mount Wilson to be globular by Hubble (Mt. W. Rep. 1920, p. 233); N. G. C. 2419, reported by Lampland of the Lowell Observatory, who also independently observed N. G. C. 6342; and N. G. C. 6453, apparently first noted at Mount Wilson by the writer as a globular cluster. The Harvard plates verify these observations.

N. G. C. 6355 and 6558, formerly classed as probably globular, are now rejected. They are not typical globular systems, but the latter may be peculiar only in the deficiency of brighter stars.

The clusters N. G. C. 5946 and 6496, and I. C. 4499, formerly suspected as globular, are now confirmed. They all appear to be of the loose type represented by N. G. C. 7492.

N. G. C. 5053 was found by Dr. Baade at Bergedorf to be an open cluster composed of sixteenth magnitude stars (Hamburg Mitteilungen **5**, 39, 1922). In view of its faintness, the object is unusual because of its relatively large diameter of 8′, and it is particularly noteworthy as being the only known open cluster apparently at a great distance from the galactic plane. N. G. C. 6544 is a condensed cluster, not globular, in low galactic latitude.

The total number of clusters now classed as globular is ninety-five.

Positions of Clusters Described from Harvard Photographs.

Designation	R. A. 1900		Dec. 1900		Galactic Longitude	Galactic Latitude
	h	m	°	′	°	°
N. G. C. 2419	7	31.4	+39	6	147	+26
5053	13	11.5	+18	12	308	+78
5946	15	28.2	−50	19	295	+ 4
6139	16	20.9	−38	37	310	+ 6
6342	17	15.3	−19	29	333	+ 9
6355	17	17.8	−26	15	327	+ 4
6453	17	44.7	−34	36	324	− 5
6496	17	51.8	−44	14	315	−11
6544	18	1.2	−25	1	333	− 4
6558	18	3.8	−31	47	327	− 7
I. C. 4499	14	45.0	−81	49	274	−21

Harlow Shapley.

Harvard College Observatory Bulletin 776.
Cambridge, Massachusetts, October 1, 1922.

N. G. C. 2419. — Harvard photographs showing N. G. C. 2419, and copies received from Dr. Lampland of a photograph made with the 40-inch reflector at the Lowell Observatory, indicate that the object is a globular cluster of uncom-

mon interest. It is one of the faintest and most distant known, its extreme angular diameter appearing to be less than 2′. It is in the constellation Lynx, about sixty degrees from the nearest known globular cluster, and nearly opposite the region in which globular clusters are mainly concentrated.

If further observation justifies the present belief that this is a typical globular cluster, the extent of the known stellar system is considerably increased. From estimates of the apparent diameter, a preliminary parallax of 0″.00002 is obtained. The corresponding distance from the Sun is 50,000 parsecs (165,000 light years), which is exceeded by only two or three clusters. The distance from the center of the system of known globular clusters is more than 200,000 light years; and the distance separating N. G. C. 2419 and N. G. C. 6517, another faint globular cluster in the opposite part of the sky, is of the order of 350,000 light years.

A better value of the parallax of N. G. C. 2419 will be given in a revision of the distances of globular clusters, which is now in preparation.

Harvard College Observatory Bulletin 776.

Cambridge, Massachusetts, October 1, 1922.

The New Heavens. — By George Ellery Hale, Director of the Mount Wilson Observatory, (Carnegie Institution of Washington). 88 pages illustrated. $1.50, 1922. Charles Scribner's Sons, New York.

Astronomy—the science of the stars, appeals to the imagination and to reason, therefore when all the facts come to us from first hand authorities, we are naturally inclined to go further in our speculation. The authority in this case is the little book "The New Heavens." Dr. Hale speaks and writes with erudition, and this little volume brings to us the summary of the latest achievements of the science, principally of the Mt. Wilson Observatory.

The book is primarily written for the layman, and the amateurs in practical astronomy, to whom Dr. Hale has always made an especial appeal. And it is most encouraging to the progress of astronomy that our great leaders in the science, such as the late Dr. Pickering, and Dr. Hale, offer to the amateur their influence and service. Coming as it does upon the final completion and test of the largest instruments of research yet known, namely the 100-inch Hooker reflecting telescope and the 20-foot Michelson interferometer, the book offers results hitherto unknown.

This little volume may serve as a companion volume to Dr. Hale's "Ten Years' Work of a Mountain Observatory," published by the Carnegie Institution of Washington, or better as a supplement to his larger work "Stellar Evolution."

The author's three essays on the recent facts of astronomical progress are most complete. He has given the subject a genetic or historical treatment and therefore places it in a proper balance and background.

The forty-one illustrations throughout are well selected and unusually good. They show the excellent performance of various reflectors, especially the 100-inch. However, without the extra good book or plate paper in the book, no halftone could be reproduced well.

Chapter one—"The New Heavens," opens with a condensed historical introduction, taking into account the early instruments and methods of making observations. The main theme is the history and construction of the Hooker reflector and the results of various tests and finally the problems to be assigned to it.

There are boundless possibilities for the work of this reflector, especially in the excellent atmospheric conditions of high mountains in California, but as Dr. Hale writes, the great cost of manipulation limits it to problems of greatest importance and beyond reach of other means of observation.

There are three great problems before the astronomer of today—and each of these involves others of lesser character, but just as essential. (1) The structure of the universe and the motion of its constituent bodies. (2) The evolution of the stars; their nature, origin, growth and decline. (3) The constitution of matter forming the various bodies of the stellar universe.

Chapter two—"Giant Stars," is in reality describing in part the second problem of the astronomer, and the work of the 20-foot Michelson interferometer. The question of giant and dwarf stars or suns is treated fully in this chapter.

The latest device, the interferometer, has as its principal function the measuring of the angular diameter of stars, and as well the angular separation of close double or binary stars. With the parallax, spectrum, and motion (proper and radial) we are in a fair way of knowing something of the stellar evolution.

Chapter three—"Cosmic Crucibles," comprises in essence the third problem of the astronomer, namely the constitution of matter. The Mt. Wilson Observatory under Dr. Hale is the first observatory to have incorporated an astrophysical laboratory—wherein it can perform experiments, imitating virtually stellar phenomena in space.

Some of the more interesting sub-sections of the chapter are Solar Helium, sun spots as magnets, stellar chemistry, transmutation of the elements, Newton and Einstein.

However much we may want to comment upon in reviewing this valuable and interesting little book—it is so completely "packed" with the latest information that we must refer the reader to the book itself. It is written authoritatively, in simple clear, untechnical language. Anyone who wishes to be well posted in the latest facts of astronomical research cannot afford to miss reading it. It will serve as a splendid compendium for the librarian who is asked, ever so often, "I should like a brief statement of the latest discoveries in science."

FREDERICK E. BRASCH.

National Research Council, Washington, D. C.

Why It Wouldn't Go. — A typical absent-minded savant from an eastern university was a member of a geological survey outfit in Arizona. One morning he found his watch at dead stop. It would not respond to any shaking and as the party was dependent upon it for observations they sent the old professor and a keeper thirty miles by wagon to a little town where there was a watch-mender. The man screwed the usual little tail light into his eye, gouged open the case, explored the works with his nut pick, closed the case, twisted the stem and handed the watch back to its owner, remarking gently: "That's a fine movement—one of the best I've seen. But you'll have to wind it."

POPULAR ASTRONOMY

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